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OF

ELECTRICAL ENGINEERS,

VOL. I.

MAY, 1884—OCTOBER, 1884.

NEW YORK CITY:
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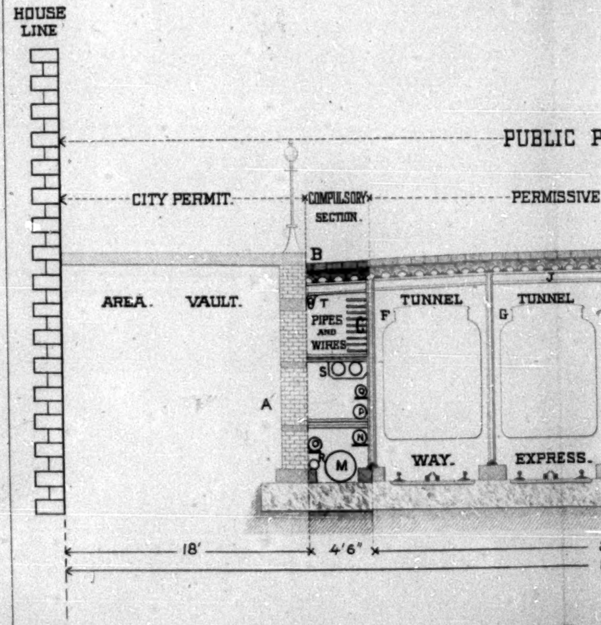
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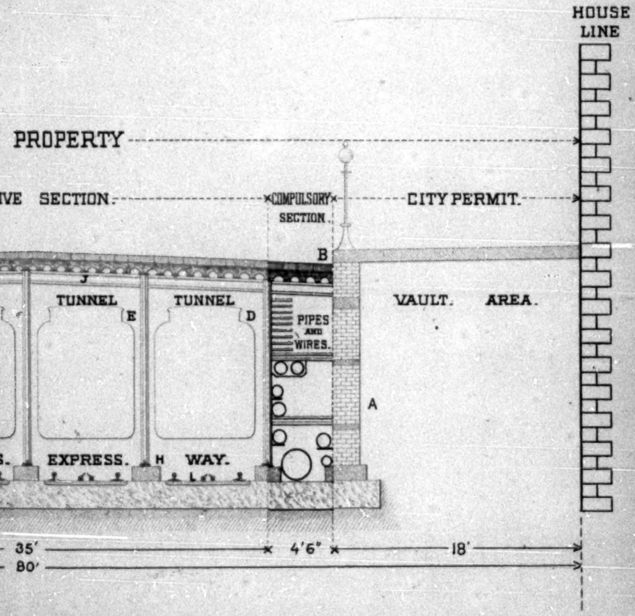
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THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The first steps toward the formation of the society were taken in April, 1884, when the following circular was issued for signatures, by Mr. N. S. Keith, of New York:

The rapidly growing art of producing and utilizing electricity has no assistance from any American national scientific society. There is no legitimate excuse for this implied absence of scientific interest, except that it be the short-sighted plea that everyone is too busy to give time to scientific, practical and social intercourse, which, in other professions, have been found so conducive to advancement.

The American Civil, and Mechanical and Mining Engineers societies, which have been so prosperous and of such great advantage to their members, are good examples.

An International Electrical Exhibition is to be held in Philadelphia next autumn, to which many of the famous foreign electrical savants, engineers and manufacturers will be visitors; and it would be a lasting disgrace to American electricians, if no American national electrical society was in existence to receive them with the honors due from their co-laborers of the United States.

It is proposed to organize The American Institute of Electrical Engineers, somewhat after the model of the American Civil, Mechanical and Mining Engineers' societies or institutes. These societies hold yearly three or four meetings, lasting three or four days each time, at various suitable places throughout the country, at which meetings the members assemble, read and discuss papers and matters relating to their trades or professions, and at the same time enjoy pleasant, personal, social intercourse, all of which is conducive to improvement and advancement in ideas, theories, practice, business and good-fellowship. The success of these societies, as well as of the various foreign electrical societies, makes it seem probable that those persons who are interested in our electrical, scientific, educational, manufacturing, telegraphic, telephonic and like concerns, as well as the users of electrical appliances generally, will find it to their advantage, personally and collectively, to establish, support, work for, and generally aid our proposed society.

It is proposed to make electrical engineers, electricians, instructors in electricity in schools and colleges, inventors and manufacturers of electrical apparatus, officers of telegraph, telephone, electric light, burglar-alarm, district messenger, electric time, and of all companies based upon electrical inventions, as well as all who are inclined to support the organization for the common interest, eligible to membership.

It is proposed to make the yearly dues about ten dollars, and to print in book form the papers, discussions and transactions at the meetings for distribution among the members without further expense. As with other societies these will be worth more than the annual dues. Affiliations with sister societies, a museum, library, original research, protection from unfavorable legislation, settlements of disputed electrical questions, exchange of volumes of transactions with foreign and other electrical and scientific societies, a journal of abstracts of papers read before other societies, or published in other journals, etc., etc., are all proposed.

The subscribers hereto hereby extend an invitation to all those persons who are eligible to membership to meet them in New York City at a place to be announced hereafter, on TUESDAY, THE 13TH DAY OF MAY, 1884, for the purpose of organizing the proposed national electrical society upon substantially the basis herein set forth.

This document was at once signed by a large number of electricians, capitalists and others connected with electrical enterprises or interested in the advancement of electrical science. It was deemed advisable, therefore, to hold a preliminary meeting, and the signers assembled at the rooms of the American Society of Civil Engineers, New York, on April 15, as founders of the proposed society.

Mr. N. S. Keith called the meeting to order and nominated Mr. Jos. P. Davis, Vice-President of the Metropolitan Telegraph and Telephone Company, as chairman of the meeting. After Mr. Davis took the chair, Mr. Keith was elected temporary secretary.

Mr. T. H. Delano offered a series of resolutions as to name, objects, membership, dues, management, committees, etc. On motion of Mr. Wm. A. Hovey, after some debate, the resolutions and the whole scheme of organization were referred to a committee of five, to be appointed by the chair, with instructions to call a meeting to hear and act upon its report. The chair afterward appointed the committee, consisting of the following gentlemen:

W. A. Hovey, President Merchants' Electric Light Company, Boston.

N. S. Keith, Electrical Engineer.

George A. Hamilton, Electrician, Western Union Telegraph Company.

Wm. H. Eckert, General Superintendent of the Metropolitan Telephone and Telegraph Company.

Geo. L. Beetle, Western Electric Company, After a vote of thanks to the American Society of Civil Engineers, and to Mr. John Bogart, the Secretary of that society, for the use of its rooms, the meeting adjourned, subject to the call of the committee.

The next meeting was held at the same place on May 13. Mr. Jos. P. Davis, chairman of the previous meeting, presided. The minutes of the meeting of April 15 were read and approved. The Committee on Organization reported that they had completed a proposed set of rules for the government of the Institute, and had nominated a sufficient number of persons to fill the offices created. The rules were then read, and adopted.* The chairman appointed Messrs. Sargent, Delano, and Ross scrutineers of the ballots for officers. The election was then proceeded with, and resulted as follows: †

FOR PRESIDENT:

DR. NORVIN GREEN, New York City.

FOR VICE-PRESIDENTS:

PROF. A. GRAHAM BELL, Washington, D. C.
PROF. CHARLES R. CROSS, Boston, Mass.
THOMAS A. EDISON, New York City.
GEO. A. HAMILTON, New York City.
CHAS. H. HASKINS, Milwaukee, Wis.
FRANK L. POPE, Elizabeth, N. J.

FOR MANAGERS:

CHARLES F. BRUSH, Cleveland, O.
WILLIAM H. ECKERT, New York City.
STEPHEN D. FIELD, New York City.
PROF. ELISHA GRAY, Chicago, Ill.
PROF. EDWIN J. HOUSTON, Philadelphia, Pa.
M. L. HELLINGS, Key West, Fla.

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* See Appendix.

† At the first meeting of the Council, held May 20, the terms of offices were determined by lot: *Vice-Presidents* to hold office for one year, Profs. Bell and Cross; for two years, Messrs. Edison and Hamilton; for three years, Messrs. Pope and Haskins. *Managers* to hold office for one year, Messrs. Jones, Hillings, Eckert, and Smith; for two years, Profs. Trowbridge and Gray, and Messrs. Field and Vail; for three years, Prof. Houston and Messrs. Brush, Weston, and Prescott.

FRANK W. JONES, New York City.
GEORGE B. PRESCOTT, New York City.
W. W. SMITH, Indianapolis, Ind.
PROF. W. P. TROWBRIDGE, New York City.
THEODORE N. VAIL, Boston, Mass.
EDWARD WESTON, Newark, N. J.

FOR TREASURER:

ROWLAND R. HAZARD, New York City.

FOR SECRETARY:

NATHANIEL S. KEITH, New York City.

The following communication was then read:

"United States Patent Office,"
Washington, D. C., May 12th, 1884.

"N. S. KEITH, Esq., *Secretary.*

"My Dear Sir:

"I find at this late day that it will be impossible for me to be with you to-morrow at the organization of the Institute of Electrical Engineers, owing to sickness in my family. It was my especial desire to be with you during this meeting and to call the attention of the members to the existing condition of the Patent Office, in relation to inventors, manufacturing interests, and in general to the advanced position among the nations of this generation, owing more than for any other reason to our liberal patent system. I wanted particularly to call attention to the Platt Bill, introduced into the Senate by Senator Platt, and providing for a Patent Office Department entirely distinct from over-ruling authority other than the Commissioner of Patents. You will confer a special favor upon me by bringing this matter to the attention of the Institute, and asking them to call upon Congress to pass the bill. It is a burning shame upon our national reputation that Congress should have permitted inventors to pay into the United States Treasury $2,500,000 over and above the expense incurred in examining and issuing patents; but such is the fact. During the past year this Bureau deposited to its credit over $471,000 more than was expended in the granting of patents for the current year. Is not this taxation without representation, and are inventors to sit idly by and submit to this while the Patent Bureau is crowded out of its building by other branches of the Interior Department?

"I transmit herewith a report to Congress by the Commissioner concerning the condition of the work in the Patent Office. I would be glad if you would call attention to my report therein in relation to the class of electricity, and beg to advise you that since it was written two of my assistants have resigned, and I am now 600 cases behind hand; so that were you to file an application to-day, it would be four months before I should reach it. It is simply absurd that the Congress of this great country does not have the foresight to realize that by thus hampering this Bureau they are throttling the onward progress of an advanced civilization and unjustly robbing the inventor of funds which the founders of the Constitution never intended should be so diverted. Every dollar taken from the inventor by this direct taxation should be invested as was intended, so as to give him such an examination as the law calls for, and to insure an expeditious examination of his application. I desire also to call attention to the fact that serious attempts have been made by Western Congressmen to shorten the life of American patents, but fortunately such attempts have all so far failed. Please give this matter your honest attention, and impress upon the Society our desire as a Bureau to be placed on an independent footing, free from all trammel, and where we can use the funds deposited by inventors exclusively for the purposes for which they are designed. It is not designed to make the head of such a department a cabinet officer, nor is such proposition desirable. Only let us be so situated that if we desire additional room, additional force or anything which will materially aid us in the transaction of the business of the Bureau we shall not be humiliated by being dictated to as to how we shall use our facilities or dispose of funds designed for a special purpose. I regret exceedingly that I cannot be with you to lay this matter before your meeting, but I feel sure that with these few suggestions you will do the proper thing.

"Pardon this long letter, but rest assured that it is only an earnest desire to see justice done both to this Bureau and to inventors that prompts me to action.

"Consider me in hearty accord with the Institute.

"I remain very respectfully yours, C. J. KINTNER,
Ex'r. Class Electricity, U. S. Patent Office."

Mr. Frankland Jannus, of Washington, D. C., stated some of his experience in his professional efforts to secure patents, especially in the class of electricity; he advocated united effort to influence Congress to do justice to inventors.

The meeting then passed the following resolution, which was offered by Prof. W. P. Trowbridge: "That the influence of the members and associates of the American Institute of Electrical Engineers should be exerted to prevent any restriction of the rights and privileges of inventors, as they now exist under the laws, and that the Institute of Electrical Engineers earnestly desires the passage of Senator Platt's bill or its equivalent, in order that the work of the Patent Office may be put on a more efficient footing."

The meeting then passed the following resolution, which was offered by Mr. George S. Bowen: "*Resolved*, That the chair appoint a committee of three who shall take such action as they may deem proper, with a view to calling the special attention of Congress to the needs of the Patent Office, especially in regard to the class of electricity."

Mr. Isaac Trumbo, of San Francisco, made some remarks on the state of electric lighting on the Pacific slope, and stated that he had been investigating various systems of lighting for use in the West.

The meeting then passed the following resolution, which was offered by Gen. C. H. Barney:—"*Resolved*, That the thanks of this meeting be tendered to the Committee on Organization, for the efficient manner in which they have performed their duties."

The meeting then passed the following resolution: "That the thanks of this meeting be tendered to the American Society of Civil Engineers for the kind offer of the use of the rooms of this Society for meetings until such time as the Institute may secure rooms for this purpose."

On motion the meeting then adjourned, subject to the call of the Council.

The following is the text of the communication to the Commissioner of Patents referred to in Mr. Kintner's letter:

REPORTS OF EXAMINER KINTNER.

DIVISION : ELECTRICITY.

Date: March, 1884.

In conformity with your order concerning the condition of the work, necessary additional force required, etc., I have the honor to submit the following report:

New cases awaiting action, 286; oldest cases awaiting action, 88; total, 374.

Oldest new case awaiting action, November 8, 1883.

Oldest amended case awaiting action, January 14, 1884.

I have now a force of eight assistants and two clerks.

This division embraces electrical appliances pure and simple, and has grown in four years so far as to include over 6,000 patents.

Prior to July 1, 1880, there were less than 2,000 patents which disclosed any electrical appliances or apparatus whatever.

Since that time, the rapid advance made in telephony, telegraphy, electric lighting appliances, dynamo machines, etc., has placed the division foremost in the arts, and the capital invested in such inventions far exceeds what could have been anticipated.

As a result, this division is burdened with applications, and improvements are so rapid that a thorough reorganization of the classification is necessitated about once in two years.

New inventions and appliances spring up; new uses are developed, and new sub-classes are, or should be, necessarily made.

With my present force, it is quite impossible for me to devote the time to the proper care of the class and of a proper reorganization, such as should be made to guarantee accurate and exhaustive searches.

In fact, the class is growing so rapidly, that another division should be made, and I have the honor to suggest that it be formed at an early day and located in rooms adjoining those now occupied by the present division.

I have no digests of foreign patents, or of the state of the art generally, during the past ten years, the most important, indeed, in its history; nor have I, with my limited force, the time to prepare such digests.

With reference, then, to your request as to the additional force, I have to suggest that at the least four more assistants should be added to the division, and that careful and accurate digests be made of all electric patents, both foreign and domestic, and of publications containing electrical subjects.

To do this as it should be done, the briefs should be made by the assistants in charge of the respective sub-classes. I am growing more and more aware of the incompleteness of our facilities, as the art advances from year to year, and in order to insure the grant of valid patents, the course here indicated should be pursued.

There is no other art embraced under our patent system which could be so thoroughly digested, and which would more fully repay for such work, for the reason that it has grown up almost entirely within the past quarter of a century.

With proper digests the class would soon be placed in such condition that a more limited force could control it.

As it is now, we are getting deeper in the mire each year; and as assistants become skilled in the state of the art there are other demands for them, and they go out of the office, carrying with them a knowledge gained only by years of research.

Since 1881 the entire *personnel* of this division has changed. Three principal examiners and four assistants have left to fill more lucrative positions outside, and the office has been placed at a disadvantage by having to educate new men to fill their places, with the probability of these men leaving at an early day.

I must again call attention to the limited rooms which this division is forced to occupy, and to the fact that the ventilation is very bad. In fact, much sickness results, and my assistants are so crowded that it is impossible to do the work required of them, either satisfactorily or with comfort.

The light is so exceedingly poor that I trust my previous suggestions concerning electric light will be carried into effect.

In response to your inquiries concerning the room, discomforts, inconveniences, etc., of this division, I beg to submit the following:

1. Numbers and location of room: 89 and 91, ground floor, F street, front; room 89, being 22 by 21 feet, and room 91, 21 by 10.

2. Eleven persons constitute the total force of the division, distributed as follows: eight in room 89, and three in room 91.

3. There are eight desks, one table, and three cases in room 89, and three desks and six cases in room 91, and the result is such an undue crowding as to very seriously impede the business of the division.

The original drawings are all located in the hall outside the rooms, and there is no light by which they may be seen.

4. The rooms are badly ventilated, and my assistants are all forced to vacate them, at least once every day, in order that they may be thrown open and aired. The light is so bad that in two instances assistants have contracted eye diseases, which were only cured after having resigned their positions.

In 91, my own room, there is no gas, and I am obliged to use kerosene oil, which seriously vitiates the atmosphere. There is gas in room 89, and much of the time gas and oil have to be burned the entire day.

The plumbing is in bad condition, and sewer gas escapes at the wash-basin. The floor is directly upon the ground, and hence excessive dampness results.

There is much sickness and constant complaint on the part of the entire force, of headache and general indisposition.

A computation of the dimensions of room 89 shows that each person has 500 cubic feet of air to breathe; during the space of seven hours this air would be inhaled and reinhaled by each person no less than six times, allowing one cubic foot per second as a healthy respiration.

PHILADELPHIA MEETING.—SEPTEMBER–OCTOBER, 1884.

The Directors of the International Electrical Exhibition, Philadelphia, held under the auspices of the Franklin Institute, having kindly tendered to the Institute the free use of rooms in the exhibition building, so long as it should remain open, the offer was accepted by the Council, and the Secretary was authorized to make the necessary preparations and to be present during the Exhibition as the representative of the Institute.

The rooms were accordingly opened to members by Mr. Keith on September 2d, and remained open until October 11th, during which time they were visited by a great many members of the Institute and by several foreign electricians. On October 7th and 8th a meeting was held, in accordance with the rules and a call, at the Continental Hotel and at the Exhibition rooms, where the papers forming part of this volume were read and discussed.* On the invitation of the Franklin Institute, the Exhibition was also inspected by the members in a body.

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*Owing to ill health, Mr. C. O. Mailloux has not been able to prepare for publication in this volume his paper on "Exploring the Field of the Dynamo-Electric Machine.

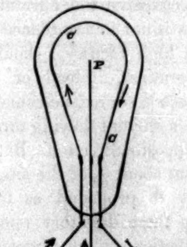
A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884.

NOTES ON PHENOMENA IN INCANDESCENT LAMPS.

BY PROF. EDWIN J. HOUSTON.

Prof. HOUSTON:—I have not prepared a paper, but merely wish to call your attention to a matter which, I suppose, you have all seen and puzzled over. Indeed, I wish to bring it before the society for the purpose of having you puzzle over it. I refer to the peculiar high vacuum phenomena observed by Mr. Edison in some of his incandescent lamps. I have in my hand an Edison incandescent lamp, having the same vacuum as the ordinary incandescent lamp. This one, however, has, in addition to the carbon filament, a platinum plate, or strip, that is thoroughly insulated from the filament, and supported in the manner seen between the two branches of the filament, as shown in Fig. 1.

FIG. 1.



An Edison carbon filament, *c*, *c*, is placed inside an inclosing glass case in the usual manner. A strip of platinum foil, P, is supported as shown inside the loop. The binding posts, P and N, are connected to the ends of the carbon loop, and O to one end

TOP

of the platinum plate. P is the positive, and N the negative terminal of the electric source.

The lamp being placed in the circuit of any electrical source, as, for example, a battery, D, the current will flow in the direction indicated by the arrows. The galvanometer, G, has one of its terminals connected with the positive terminal, P, of the electrical source, and the other terminal connected with one end of the platinum strip, or plate.

3b

P, representing the positive terminal, the current may be conceived as flowing through the filament in this manner. [Indicating.] If the ordinary current used in producing the light is passing, then no unusual effects are noticed. If, however, the current is increased, so that the incandescence of the filament is raised from its normal, say, eight candle-power, to twenty—, thirty—, forty—, fifty—, or one hundred candle-power, then the needle of the galvanometer is violently deflected by a current passing through its coils.

The question is, what is the origin of this current? How is it produced? Since we have within the globe a nearly complete vacuum, we cannot conceive the current as flowing across the vacuous space, as this is not in accordance with our pre-conceived ideas connected with high vacua. I should mention here, that if the galvanometer terminal, instead of being connected with positive, P, of the electric source, be connected with the negative, N, then we also have a current flowing through the galvanometer, but this time in the opposite direction. But in this case its amount is much less, being but about $\frac{1}{40}$ of the amount of the first current.

I have no theory to propound as to the origin of these phenomena. I make these desultory remarks merely because I wish to call your attention to the phenomena, if you have not already seen them. It is very clear as to the direction in which the current flows, when one end of the galvanometer is connected with the positive terminal, P. This I have traced by observing the direction of deflection of the galvanometer needle. The current flows, not as we might suppose, from the carbon to the platinum; it flows apparently in this direction, as if it came from the platinum. If it flowed as though it went from the carbon to the platinum, then it might be ascribed to various causes. It may be electricity flowing through empty space, which I don't think probable; or it might be the effect of what may be called electrical convection, if there is such a term. The Crookes' discharge from one of the poles might produce an electrical bombardment against

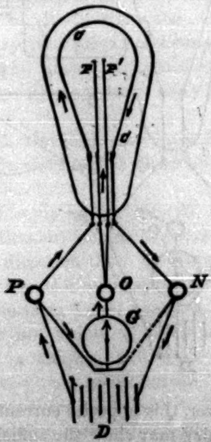
18 TOP

the plate, each molecule taking a small charge that might produce the effect of a current.

If we conceive, as I think most probable, a flow of molecules passing from the platinum to the carbon, then the phenomena may be readily explained as a Crookes' effect, since then we can regard a current as flowing in parallel circuit, from P, to N, through the carbon loop, and from P, through G, O, and P, to the carbon loop. But, remembering that the direction of the current is reversed, or apparently so, when the galvanometer is connected with the negative terminal, N, then the difficulty is to understand how the current there produced could possibly overcome the current from the source supplying the lamp. I should say here, however, that I am not entirely convinced from the few experiments I have tried myself, as to the actual existence of such a current. The deflection of the galvanometer needle, when connection was made with the negative terminal, being quite feeble. I am assured, however, that decided deflections have been observed.

I saw another lamp, in which two platinum plates are placed inside the lamp, but unfortunately I have not succeeded in finding the gentleman exhibiting it, so as to obtain from him an explanation of its peculiarities.

FIG. 2.

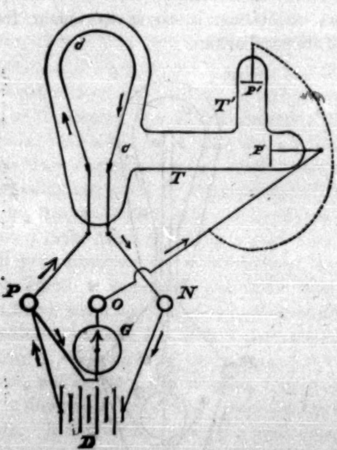


In this lamp, as shown in Fig. 2, the parts are the same as in Fig. 1, only two platinum strips, P, P′, placed parallel to each other, TOP

are employed. If a current is produced when the terminals, O, are connected with the galvanometer, then the phenomena is still more difficult of explanation. I believe, however, that one pole of the electrical source is always connected with the galvanometer, the other being connected with either or both of the platinum terminals. If such is the case, then the phenomena are simply modifications of the preceding.

I believe we shall find the preceding phenomena worth looking into. For my own part I am somewhat inclined to believe that we may possibly have here a new source of electrical excitement. That in some way the molecular bombardments against the platinum plate may produce an electrical current. At least, supposing it to be true that when the terminal, N, is connected with the galvanometer, the current through the galvanometer flows in the opposite direction to the current from the electrical source, it would seem that the phenomena could not be ascribed to the Crookes' effect.

FIG. 3.



Supposing, however, this opposite current out of the way, then a more careful inquiry may show the sufficiency of the Crookes' effect for the explanation of the phenomena. Indeed, an experiment Mr. Edison has made, would appear to throw no little light on the matter. Instead of placing the platinum pole, P, inside the carbon loop, it was placed in the end of a long tube, T, T′, forming a part of the lamp case. When the connections were made, as shown, with the platinum at P, so as to place it in line with the carbon, and, therefore, expose the filament to the bombardment of the molecules shot out from the platinum, the needle of the galvanometer was deflected, even though the tube, T, was surrounded by a freezing mixture. When, however, the platinum was placed at P′, in the branch tube T′, out of the direct line of the carbon, no effects were observed in the galvanometer.

I have brought this matter before you in this crude way, thinking it may be interesting, and that it might possibly elicit a discussion which would aid us in ascertaining its cause.

Mr. KEITH:—May I ask if the current always flows from the platinum plate towards the carbon?

Prof. HOUSTON:—I am not sure; I think in one case it flows from the carbon to the platinum.

Mr. KEITH:—That mystifies the matter still further.

Prof. HOUSTON:—Certainly.

Mr. KEITH:—It seems to me that there is a galvanic couple. It will be, provided that at all the times the current flows from the platinum, reaction may take place; or even if it flows from the carbon to the platinum, no matter whether constantly or not. The remarks that I was going to make are spoiled by lack of data on the subject.

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Mr. PREECE:—Prof. Houston, may I ask you on what grounds you assert, or anybody asserts, that electricity flows in one direction rather than another?

Prof. HOUSTON:—Simply on the ground of its being a definite idea. I don't know that any one could prove that electricity flows more readily in one direction than another; but we have a convenient way of speaking of it as flowing from a higher to a lower potential. I think the facts would appear to warrant us in saying so. Of course, I do not know whether it is so or not. For my own opinion I would say that I think electricity is the transmission of chemical or atomic action, and I speak of it as flowing, or being transmitted, in a definite direction.

Mr. PREECE:—For that reason I asked the question, because there is no difference as to the use of the term or the definition or

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value of the current; it is a pure convention. I do not think that we have any facts of any sort or kind to justify us in assuming that electricity flows in one direction rather than the other; but I would mention this, that in all recent inquiries that Crookes has made, and also Spottiswoode, before his death, they all had the tendency to show that if electricity does flow at all in any direction, that direction is rather from the lower to the higher potential, than, as we are all accustomed to admit and believe, from the higher potential to the lower potential. In other words, the tendency of the inquiry of Spottiswoode, De la Rue, and Crookes, and one or two German inquirers, whose names at present I forget, all rather tend to confirm your suspicion that electricity flows in the reverse direction to that which we are accustomed to admit.

Every other electrician present at the Exhibition, I think, has watched this experiment with very great interest. I feel puzzled in reference to it, and I feel that it is one of those things that wants to be very carefully and cautiously examined. It is also one upon which it is very dangerous to express an opinion. I was foolish enough the other night, when the experiment was shown to me at Mr. Edison's exhibit, to express an opinion, but I regret that I did so. However, I intend to exercise my persuasive eloquence upon Mr. Edison when I see him next week to induce him to give me one of those lamps, and when I go back to England I shall certainly make an illustration before our society there, and then make a careful inquiry into it. My own idea of electricity and the nature of this experiment is this: That for the production of the current you must have two things; you must have two points at different potentials, separated from each other by matter, and in this whether the direction be from the positive to the negative, or vice versa, is a matter of very little consequence; but to produce a current, as we have it here, we must have two points separated from each other by matter. The principal point here is what is that matter, and where is that matter.

I saw at Montreal an excessively beautiful experiment, tending to show that you had a Crookes' effect from platinum and carbon, just as much as we know that we have an effect from carbon and anything else. We know, for instance, in every incandescent lamp, that when you raise the filament to a certain condition of incandescence, there you have the Crookes' effect, because we see the carbon deposited upon the glass. But when we have platinum, it is a very difficult thing to prove that there exists the Crookes' effect. Dr. Oliver Lodge showed an extremely pretty experiment, to illustrate the fact that fogs resulted from the formation of moisture around a nucleus or molecule of matter. He took a large glass globe, apparently chemically clean, exhausted the air, but with moisture in it. It remained perfectly transparent as long as no matter was admitted, but the moment a spark from an induction coil was passed between the two platinum electrodes in this apparently chemically clean tube, at once a cloud was formed throughout the whole of the tube, showing that the passage of the spark between those two platinum points produces a Crookes' effect. That is, there was a bombardment of the platinum molecules, filling the whole of the tube, and the result was, the fog was formed. Now, here, suppose that that shall form, it may be, as has been suggested, that there is a new source of electricity. It may be it is due to something that we don't know of at the present. I am quite certain that we shall find the cause of this remarkable phenomena to be due to the Crookes' effect.

Prof. HOUSTON:—I would like to say, in answer to the gentleman who has just spoken, that I am aware of the experiments that he has mentioned, some of which have been urged as proving the existence of a negative current. It seems to me that all they show is the transference of matter from the negative to the positive pole. Now, whether that constitutes an electric current or not, I do not think we can quite determine. The peculiar thing about the experiments I have mentioned is in the reverse direction of the current when the galvanometer is connected to the negative terminal. The difficulty exists, however, in finding a satisfactory explanation of the phenomena observed; whether the current is flowing from the positive or from the negative.

Mr. KEITH:—Mr. Chairman, I think the remark, or word, the convention, of assuming a direction for the current, may be used in electrolysis. The current may be considered as carrying metal from the anode to the cathode, and thereby producing a deflection of the galvanometer needle, or a positive-direction wave constantly to the right hand, or to the left hand, as indicated by the deflection of the needle. However, I have often noticed in arc lamps this fact: when we have a very long arc there oftentimes comes a sweeping movement around the ends of the positive and the negative carbon, and there is a little flame proceeding from the negative carbon towards the positive, which seems to rise, and have its point, or beginning, as we may say, upon the negative,

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running up like a brush towards the positive. You have current enough to spread around this surface, or portion of the surface of the upper carbon, seeming to emanate from the negative and proceeding to the positive. It probably has been noticed by everyone who has worked the arc lights, that same phenomena, as though something was passing from the negative and going to the positive. This cannot be quoted as an illustration of the transference of carbon from the positive to the negative, as is manifested upon the negative carbon when the short arc is used.

Mr. **Preece**:—I think that some similar phenomena are noticed with the long platinum wire when it is raised to the state of incandescence. You find the heat commences at the negative end and flows in the other direction from some cause.

Mr. **Kelly**:—Some explanation ought to be given in reference to incandescent lamps at a high temperature. As to the current, I would say there is a discharge from one side of the carbon to the other. That is noticed to some extent in the same plate. Perhaps the induction is strong between the two sides of the carbon. Now, I don't see any special reason for supposing that when the platinum circuit is closed the discharge is interrupted; instead of passing from one carbon to the other, the discharge takes place between the negative side of the carbon and the platinum plate.

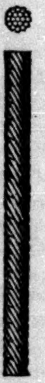
A paper read by Mr W. M. Callender before the American Institute of Electrical Engineers, at Philadelphia, September, 1884; with discussion thereon.

UNDERGROUND WIRES.

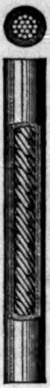
The question of underground wires is now one of such universal interest, and one upon which opinions differing as widely as the poles are so freely expressed by those whom the public consider as its leaders, that I venture to think it may be of importance for this meeting to consider frankly what has already been done toward this end.

Underground wires may be roughly divided into three kinds—lighting, telegraph and telephone. That the placing underground of telegraph wires in cities presents no unsurmountable difficulty, either mechanical or electrical, is acknowledged by all electricians. It is only necessary to refer to what has already been done in Chicago and Washington to prove this practicability. The placing underground of telephone wires is also admitted to be practical, and no doubt many of you have recently had the pleasure of listening to Mr. Berthon, of the Paris Telephone Co., describing how successful has been his underground telephone system in Paris. Mr. Edison proves every day that wires for incandescent lighting can convey their current underground, and work, he claims, satisfactorily, and it is only when we come to the question of "arc" wires that any real difficulty has been experienced. That, however, it is possible to put arc leads underground, there is no room to doubt, and I purpose to point out to you, first, what are the special points necessary to insure a successful underground arc system, and second, where such a system is in practical use.

To place wires of any kind underground some sort of a conduit or receptacle is quite necessary, and while a tunnel or sub-way under every street strikes one at once as being *the* way out of the difficulty, still such a scheme must at once be discarded, in view of its cost, until such a time as the telephone and the electric light are in use in every household. Until that happy day the underground system, I think, will be somewhat piecemeal. Each telephone, each light and each telegraph company will no doubt try to work its own wires in its own way, to have its wires in its own conduit, allowing no rival to have access to them. Admitting this, let us see how this can be worked out. The problem before us is; suppose all the telegraph and telephone lines underground, how to place the electric light wires so that they will *work* and not incommode either their telephonic or telegraphic neighbors. A telegraph line is not injuriously affected by an arc circuit, even if in very close proximity, provided, as is always the case, there is a return wire for the arc circuits. A telephone wire is practically useless if in its neighbourhood there is an arc circuit, but if instead of using a single wire for your telephone, you use a metallic circuit, your instrument is in no way affected, and you get satisfactory results. These are, in a word, the conclusions arrived at after a long and thorough investigation into the subject of induction, made by the Gramme Committee last winter—and I think they are pretty generally accepted.



CABLE WITHOUT
INSULATION.

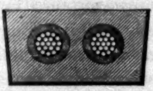


CABLE WITH
INSULATION.

When arc lighting was first started here, overhead wires were of course adopted, and it is no doubt largely owing to their cheap construction, that arc lighting has made the wonderful strides it has in this country; and now that the public are clamoring for the removal of the unsightly poles which disfigure their streets, the companies are loath to sacrifice so much original expenditure, as in so many cases where they have tried an underground system the result has been failure and loss, till now the feelings of the light companies toward the underground question is one of great caution and unbelief. I think all the companies are agreed that, if their wires can be placed underground, it is to their interest to have them there. Their scepticism is not to be wondered at, when we, as practical men, listen to the nostrums so frequently propounded by the many electrical quacks.

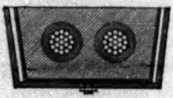
For underground work, the first thing to be decided upon is the conduit. There are many things which influence a decision as to its size and shape, but the following are absolutely necessary.

If it is under a street, it must be laid solidly, so that it cannot be shifted by the weight of the earth over it, and be strong enough to withstand the pressure and concussion of the traffic. It should be water-tight, and so arranged that the wires can be readily got at, when necessary, either for repairs, or when required to be tapped and a branch line taken from them, and above all it *must be cheap.* I have before me two sections such as have been successfully used in England, and these I will explain later on. The cheapest conduit which will naturally occur to you is an ordinary cast-iron pipe or a wooden trough, but both of these have their disadvantages. A cable for underground electric cable lighting is necessarily a costly thing, and the old maxim that insulated wire should be treated with respect, and as carefully as a new-born baby, is doubly true in respect to it. It is bad policy to haul any insulated wire through a pipe. It lays the cable open to damage and weakening at the hands of careless workmen, and this, where possible, should be avoided. In laying a new line it is therefore advisable to have the top of the conduit removable, and to *lay* the cable in it, thus saving any chance of injury. A wooden box does not, in practice, answer so well as iron, and its economy, in England, at least, is *little.*



End View of Cables Embedded in Bitumen, Ready for Laying in Road.

Having settled the question of conduit, the next question which arises is, what is the best conductor to use? The conductor must, of course, be of the purest copper, and it is to be preferred in the form of a strand, rather than as a solid wire. A stranded conductor need cost but a trifle more than a solid wire; it is more easily handled, and thus renders the cable less liable to damage. It presents a larger radiating surface, and is in every way preferable. The insulation of the conductor is of supreme importance, as upon its properties depends the success or failure of the circuit. When a high tension current is used with an E. M. F. of about two thousand volts, everything must be of perfect workmanship. A charge of this magnitude rushing through the wire tests and tries its capacity to the utmost. Any weak place in the insulation is soon found out, and a leak once started, the cable is doomed. The electricity will find its shorter way home, consuming everything in its course. It is, therefore, absolutely necessary that the insulation be such as will withstand a high tension current; that the workmanship be perfect; and, most important, that the insulation be protected from any danger of mechanical damage.



SECTION OF JOINT.

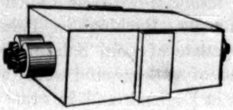
The only three insulating materials that need be considered are gutta percha, rubber and its compounds, and bitite or vulcanized bitumen—paraffine and the numerous cotton coverings, although very useful in their own place, are no good for underground, they will neither stand the dampness, nor in fact can they ever be considered as "insulating" a wire. For you cannot consider a wire insulated, unless when after soaking in a tank of water, and testing by means of a Thomson's galvanometer you get a high insulation resistance. A perfect underground wire should have the following qualities.

a. It should be permanent and unchanging.

b. It should have an affinity for the earth, and be unaffected by earth acids and changes of temperature.

c. It should be cheap, a good insulator and reliable.

The most famous of all insulators is certainly gutta percha, its tenacious gummy nature adapts it admirably for that purpose, and when under water and unexposed to the atmosphere it is recognized as the standard. The conductors of most submarine cables are insulated with gutta percha, and when electric lighting first became a fact, gutta percha was used in preference to all others.

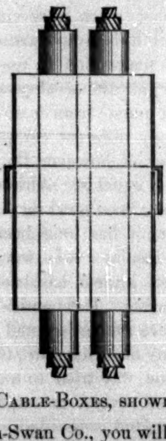


CABLE AS LAID.

The objections to its use for underground purposes are, however, grave. While it is under water its life may be very great, but used in the dry it often rapidly deteriorates, the natural gum exudes and leaves only a brittle resin, which soon becomes useless. It is very susceptible to temperature, and cannot be handled with safety in a higher temperature than about 84° F., and thus, in this climate it is practically useless for underground electric light purposes.

Vulcanized India rubber (when pure virgin rubber is used) is also a good material, but it is always treacherous and uncertain even when best, and the temptation to use old and spent rubber, and to doctor it in its vulcanization, is always great—and soon tells. You cannot make a silk purse from a sow's ear, is a good old proverb. There are many different compounds of rubber, some better, some worse. After all, however, they are simply imitations of pure rubber and seldom equal it. Although both gutta percha and India rubber have long been good servants to electricians, and especially to telegraphists, it has long been felt that some new, cheaper and permanent insulator was wanted. Bitumen, as *the* most permanent substance known, has been a favorite field for chemists and experimentalists. Its chemical composition being so nearly allied to that of pure rubber, seemed to invite experiments, and I hardly know of any electrician of standing, in England at least, who has not in some way tried to make use of it as an insulator. Failure followed every attempt until Mr. W. O. Callender, of London, England, succeeded some years ago in producing this material "Bitite," or vulcanized bitumen, in which, by a peculiar secret treatment, he preserves all the lasting properties of bitumen, and adds to it many of the characteristics of rubber. A mineral insulating material is thus produced, which, having an earth as its basis, is perfectly suited for underground, while its low cost invites its use. Theoretically, it is *the* most perfect of all underground insulations, and is accepted as such for all heavy work in England, and there in almost every important installation the main cables are insulated with the Callender Co.'s "Bitite." The House of Commons, Buckingham Palace, the New Law Courts, London, the estate of Lord Salisbury at Hatfield (where there are many miles of underground work) are among the best known installations in England, and in every case the "Bitite" wire in service is underground. It is used by the War Office, Admiralty, Indian Office and other departments of Her Majesty's Government, all the leading companies, Brush, Swan, Edison, Pilsen-Joel, Crompton, Maxim-Weston, Rogers, Fife Main and Jablochkoff, and in every case it is recognized as *the* wire for heavy underground work.

Naturally every street to be lighted presents special features to be treated specially, and if I describe several of the different systems already laid by the Callender Co., and the plans elaborated by them for the Edison-Swan Co., you will see their practicability and appreciate their simplicity and comparative economy.



PLAN OF CABLE-BOXES, SHOWING FRONT.

In some cases where it has been found impossible to *lay* the cable, it has been necessary to draw it through a pipe. At Hatfield several of the cables were drawn through ordinary earthenware drain pipes, and in one installation for the Jablochkoff Co., where about twenty miles of cable were used, it was pulled through iron pipes, and I may mention to show what some people think of insulated wire that in this case it was drawn through by horses. How that wire did escape ruination has always been a subject of wonder. At Eastbourne, a town about fifty miles from London, lighted by the Brush Co., the wires are nearly all underground and work well. There the wires are drawn through an iron pipe, and a considerable part of them are insulated with "Bitite." In London itself there is not much permanent arc lighting, and there, where the system of pulling through pipes is not carried out, the following plan has been adopted :

An iron trough has been laid solidly, and coupled as shown in the sketch, and in this at intervals of about 18″ are placed bridges, made of insulite, a special preparation of bitumen, and on them the cable is laid. The bridges are inexpensive, and practical men will at once see their advantage in keeping the cables equally distant, and in facilitating their laying. When the cable is laid, pure melted bitumen is run in so as to cement cables, bridges and trough into a solid mass. Care is taken that the heat of the bitumen is not such as to injure the cables, but just sufficient to make a solid mass. The cables once laid upon this plan cannot go wrong, no injury can get at them; and you thus have a permanent piece of work. You may say that such a scheme is faulty, because it does not allow you to increase your number of cables without tearing up the street—although when the gas companies require larger mains, they are obliged to open up the streets. Still our difficulty may be overcome by laying such mains as are required at once, and allowing a free space over them in which the cables might be drawn in if necessary. The wires can be tapped and connection made easily in something like this way. The lid would be removed and the hard bitumen chipped off till the cable was exposed. A hole would be cut in the side of the conduit and to it would be screwed an ordinary gas pipe, making a water-tight joint, and through this pipe a branch house cable could be brought and joined in the ordinary way to the main cable; replace carefully the insulation and then pour in some more melted bitumen, and the deed is done—your connection is complete. Substantially, this is the scheme prepared under the instruction from the Edison Swan Co., and while its efficacy is certain, it scost is comparatively low. The main cables at the New Law Courts, London, and the cable for the Brush Co. (arc lights) at Plymouth, as well as many others, are on a modification of this plan. Granted the efficiency of this scheme, the question of cost is of next importance. Where there is only one wire to be laid, the cost is, of course, proportionately high. Where a larger number of leads can be laid, say eight wires (4 circuits) the cost of cable, conduit, bitumen and labor should be decreased to about twenty-five cents per foot per wire. These figures are, of course, only very rough, but are enough to give you an idea of the cost. It must be recognized that every piece of underground work is a special piece of engineering where special difficulties have to be overcome, and a scheme that is in all its details perfect for one place, may not be at all adapted for another, although the cost of each installation need not vary very much. That with such an underground system as I have described, the actual working expenses of a plant will be decreased goes without saying. The insulation will be more perfect; failures altogether done away with, no chance of interference owing to weather, and no breaking down of wires, are among a few of the advantages to be reaped from such a system. That the original cost of such a plant would be higher, is also true; but I maintain that true economy is not arrived at by the erection of the cheapest kind of work, but by the erection of some solid, permanent system, in which maintenance does not form one of the chief items, and such a system I have had the honor of laying before you to-day.

In conclusion, let me frankly state, that what I have advocated should be taken as "principles," not so much as "details." And these principles are—1. That to have an underground system for arc lighting, you must have a thoroughly insulated wire, and that such insulation must be able to withstand a high tension current without deterioration, and must be reasonably permanent; and 2. That the cable must be thoroughly protected from mechanical damage, must be easily got at, and must be easily tapped.

The scheme I have explained to you is the result of practical experience; it is not a fancy plan, simply evolved from out the imagination. It has withstood the test of two years' experience in England, and is to-day as perfect as when laid down, and it is acknowledged to be perfectly successful, and is admitted to be the cheapest scheme known, and, I am confident, will prove equally successful here.

DISCUSSION.

The Chairman (Mr. W. D. Sargent): Has any gentleman present any remarks to make on the subject of this paper? I would like very much to hear from Mr. Preece in regard to underground wires.

Mr. Preece: Is this a question of arc lighting by means of underground wires?

The Chairman: Outside of that there are persons here who are interested in other underground wires, with which you are very familiar.

Mr. Preece: I have been striving very hard during the whole of my stay in this country to prevent being drawn into a discussion of this question of underground wires, and I am bound to confess that my first sensation on hearing the title of Mr. Callender's paper read was to take up my hat and walk, but that would have been an act of discourtesy to the members present, if I had done so; therefore I sat it out, and I have submitted to this very painful ordeal placed upon me by your President to say something on this much vexed question.

Now, it is not a vexed question in England. The question of aerial wires and underground wires is not a problem to be solved; it is a problem that has been solved; and whether a wire be put under ground, or whether it be put above ground, is simply a question of pounds, shillings and pence. As Mr. Callender has said, it is an engineering question, and if any town or village or any landlord wants a wire to be put under ground, he simply has to call in any ordinary English electrician, and he would not be competent to maintain the title of electrician unless he was able to give a clear, impartial and fair estimate of the conditions determined by putting the wire under ground. We know the cost, we know the durability, and we know exactly what to do in any case, whether it was arc lighting, incandescent lighting, telegraphic work or telephonic work. But I am far from saying that what governs us in England would govern you in the United States. I would not for a moment admit that the experience that we have had with underground wires in England is necessarily the same experience that you ought to have had. You ought to have done this years ago in the United States. But the conditions are totally different. You have a different climate, and you have different atmospheric conditions, and you work your telegraph in a very different way. You have a greater distance to go over, and you have both those extremes of heat and cold that we never get in our experience on the other side of the Atlantic Ocean. Hence our experience is not necessarily your experience. But with that experience on that side of the water, I don't think there is an engineer, however competent he may be for designing underground work in England, who is not equally competent to design underground work on this side of the water. Why it is you have delayed the solution of this question with you so long I cannot make out. When I was here, seven years ago, I saw your corporation spending heaps of money in beautifying your streets and in the erection of beautiful buildings, and then allowing them to be disfigured with those hideous posts overhead with wires strung on them. The only advantage that I have yet observed with those overhead wires has been that in hot weather in some place they form very convenient shade. Beyond that I know of no earthly reason why they should be put up. But while you have in this country gone to one extreme, that is in avoiding underground wire altogether, there is a strong tendency somehow to drive you to the other extreme, and that is to force you to put your wires underground. Now, I know the old story about leading the horse to the pond—you cannot make him drink, and I know quite enough of the American character to know that you cannot force telegraphic companies and telephone companies in this country to go under ground against their will. They must be led up to it gently. It is not ridiculous legislation, and it is not the passing of impractical and absurd measures that will force the wires under ground. It will be a gradual teaching of experience in reference to the working of the companies. I have come in contact, since I came here, with a good many telegraph people. I find they all say, and I am sure they are quite true in what they say, "Show us a practical underground system and we will adopt it." Well, I saw several experiments going on, and I can speak from experience of Mr. Callender's system. All he has said I think is to be recommended. In several instances we have given it a very fair trial on the other side of the Atlantic, and we have tried it faithfully and impartially, as we try every new system that is brought to us, solely on the question of pounds, shillings and pence. And from my own experience I can confirm all he has claimed for his material. We use it in pipes, and we also draw into those pipes copper wires coated with gutta-percha. We are perfectly satisfied with gutta-percha. We know exactly how much to allow for renewal.

We know exactly the durability. All we want now is to have some substance that will give us the same advantages as the gutta-percha at a cheaper price. At the same time it is a question of pounds, shillings and pence. We know how much it costs us to maintain wires over ground. We know that if we have more than fifteen wires we go under ground, because it is cheaper. That has proved to be the case in England, and we put our wires under ground, because it is cheaper than to go over ground. But there is a serious disadvantage in underground wires, and one which would be felt here more than any other, and that is the retarding effect upon the working of the telegraph with the underground system when it is used. With the insertion of every mile of underground working we have a reduction of the rate of work. On such a circuit as between London and Glasgow it amounts to one word per minute, and in working from London to Glasgow at the rate of two hundred words per minute, if we had ten miles of underground the rate would have to be reduced to one hundred and ninety, so that we find on such a circuit that the insertion of this underground portion retards the rate of working.

Again with the telephone. I have heard many people say on this side of the Atlantic that you cannot work the telephone under ground. Well, that is simply an absolute mistake. You can work telephones under ground as well as you can work them over ground, but within limits. We have at Newcastle, in England, a very extensive telephone exchange with seven hundred subscribers. Newcastle is a town of over one hundred thousand inhabitants, and the whole of that system is worked with an underground system with no difficulty and no trouble of any sort or kind. But, again, there are limits. This question of static capacity that retards the rate of working all automatic circuits takes off the fine waves of sound that render articulation clear; and as you add mile upon mile of underground circuit, so your articulation diminished until at last you get to the point where articulation for telephonic purposes is practically difficult or impossible. The distance on wires that we use now, or the length of work, is twelve miles.

Within twelve miles you can work the telephone system on a metallic circuit as efficiently under ground as you can over ground.

Now, I say you have gone to the extreme. You have up to the present moment ignored underground working altogether. But there is danger of your been forced to the other extreme, of being forced under ground, although I do not think you will be so forced. I think the true solution will be as much as possible a matter of expense, as all telegraph companies and telephone companies will learn. They are perfectly willing to use an improved system of underground work. The people themselves would not admit of that destructive policy of cutting down the poles with axe and saw. I am told that in one town not a hundred miles away from Philadelphia, on the first of January, an armed body of men will turn out with axes and saws, and will cut down every telegraphic post in that city. I don't think it is at all likely that that will be done, for even the thought or idea is suicidal and foolish, and the public would not submit to it for one minute. Therefore on this question what I have to say is, judging from our experience in England, the underground working is as simple as A, B, C, and the more the question is examined, the more these new systems are tried, the more telephone companies will take a little more sense into their councils and try, so as to satisfy the public that they are trying a little underground working, and the telegraph companies the same, then the sooner will this question be settled, and the sooner will poor, unfortunate engineers like myself, who come over here, the sooner we shall be—I forget the exact words I want to use—the better pleased we shall be in the future to come over here with the hope that in running over for five or six months we shall escape from outside pressure and obtain needed rest. [Applause.]

A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884; with discussion thereon.

SYNCHRONISM.

BY PROF. EDWIN J. HOUSTON.

Among the many practical problems whose solution has long been sought for, but sought for in vain, until very recently, is the problem of obtaining approximately absolute synchronism.

A pendulum completes its to-and-fro motion, or oscillation, in a given time, that is independent of the distance through which it swings, or, in other words, independent of the amptitude of its oscillation. The time required to make one complete oscillation being exactly the same as that required to make any subsequent oscillation. This fact is expressed when we say, that the oscillations of a pendulum are isochronous.

When we include the idea of any one event happening in exactly the same time as that required for another event to happen, we express this fact correctly by saying that the movements of the two are synchronous. That is to say, the two not only start together, but complete all parts of their motions in the same time.

In order to render the preceding clearer, let us suppose that two tuning forks be started in vibration. Either fork will continue to make isochronous vibrations, if the time required by such fork to complete any single vibration is the same as that required to complete any subsequent vibration. While the vibrations of either fork may be isochronous, it does not follow that the vibrations of the two forks are synchronous.

Either of the two forks may be isochronous in its motions, although one of the forks may make 256 vibrations per second, while the other makes 512 vibrations per second. Either of the forks is isochronous, because it requires the same interval of time to complete any single to-and-fro motion; but the two forks are not synochronous, since one of them makes 256 vibrations per second, while the other makes 512 vibrations. In order that they may be synchronous they must each make the same number of vibrations in the same time.

The modern idea of synochronism includes the additional notion that the two bodies must not only move through the same distance in the same time, but that also their motions during the entire time must be exactly similar, that is to say, that they must be synchronous at all points during their movements.

Let us suppose, for example, that two pendulums be started at exactly the same time and be permitted to swing for, say, one minute. It does not at all follow that because they make the same number of oscillations during that time that their oscillations have been necessarily synchronous throughout the entire time of their movements, that is throughout the entire minute; since, in accordance with the definition of synchronism we have above given, it is not only necessary that the two bodies shall have moved through an equal distance, or, in other words, shall have started and stopped at the same time, but that they shall have been synchronous in their movements throughout all parts of the entire number of vibrations made.

Many attempts have been made to attain synchronism, but up to within comparatively recent date, it would seem that these attempts have been unsuccessful in obtaining the synchronism to which reference have just been made; that is the synchronous movement, for an indefinite period of time, of free moving bodies mechanically independent. For example, a ratchet wheel and cog-wheel, controlled by pawls, star wheels, friction or other mechanical devices may be approximately synchronous in their movements, but with such movements I do not propose to treat, since they could not well be otherwise than approximately synchronous, and are not involved in a proper understanding of the term.

For example, the House Printing Telegraph, Hughes' Printing Telegraph, Calahan's Stock Printing Telegraph, Edison's Chemical Stock Printing Telegraph, Meyer's Multiplex Telegraph, Baudot's System of Telegraphy, Casselli's and Bonnelli's Autographic or Fac-Simile Telegraph, and Edison's Autographic Telegraph, are all operated by mechanically synchronized movements, which are brought into unison at given times by certain mechanical devices electrically controlled, which bring them to a full or partial stop by certain mechanical impediments, frictional or otherwise, to their free motion, and these corrections being in all cases prearranged, are made use of whether the movement of the machine requires them or not.

Such movements, however, are not comprised in the idea of synchronism as it has been above defined, nor are they worthy the designation of synchronous movements, since their movements are never free or independent of mechanical appliances. They merely afford instances where different apparatus are maintained in a somewhat approximate synchronism for a very brief interval, when they are stopped, brought into unison, and again started.

A considerable stride in the direction of true synchronism was made by Prof. Paul Le Cour, of Copenhagen, whose genius has created the phonic wheel, a contrivance by means of which a rapidly interrupted circuit in an electro-magnet keeps in even rotation an armature wheel, the impulses of the magnet being made effective by increments so fine on the armature wheel that a uniform movement, hardly attainable by any other known device, is produced.

In strong contrast with the previously mentioned efforts towards synchronism, we have to-day the practically perfect synchronism of Mr. Delany, who, with marvellous ingenuity, has succeeded in obtaining and maintaining synchronism in the highest and best sense of the term.

I will be better understood when I call your attention to the fact that he has succeeded in keeping two bodies, separated by hundreds of miles, in synchronous rotation for periods of upwards of seventy hours, without variation during that time of the $\frac{1}{1000}$ part of a second. This is equivalent to two entirely independent bodies, separated from each other by hundreds of miles, starting together and passing through a distance of nearly one hundred miles without varying the $\frac{1}{100}$ part of an inch in that entire distance, or the $\frac{1}{1000}$ part of a second during that entire time.

The period of seventy hours I have mentioned, has no significance, so far as the limit of time is concerned, since these movements can be maintained for weeks, or months, or even for an indefinite period, with a like degree of accuracy; it being only necessary to keep the Voltaic batteries, used in this system, in working order.

Mr. Delany has chosen for his system the phonic wheel of Le Cour as affording the movement the best suited for regulation by his synchronizing device.

I will pass over the results he has already obtained in the shape of multiplex telegraphy, which, as you are probably aware, has been in successful practical operation under his system for some months past. In this system, circuits, ranging in number from six to seventy-two, according to their capacity, have been obtained over a single wire, admitting of the transaction of from six to seventy-two separate messages, at practically the same time, either all in one direction, or any portion of the whole number in opposite directions. These circuits so obtained may be adapted to the Morse system or to the printing system, the Morse system being applicable up to twelve circuits at the ordinary rates of transmission; the speed of any number of circuits being dependent on the number of connections that any particular instrument gets with the line in a given time.

The operation of the Morse system by the Synchronous method involves a feature that has probably never been explained, and to it I will therefore call your particular attention. If we consider that for one complete rotation of the synchronized distributor, which constitutes one end of the line, the line passes over 72 contacts, which may be used for the transmission of messages, and, that under the sextuplex organization, each of the six operators' instruments would be connected to twelve of these contacts in the circle, and that the distributor rotates at the rate of 2⅚ times per second, we will find that each of the six operators' instruments would be connected to the line 12 times for each complete rotation, or 34 times per second, and that all these operators have been put in connection with the line, and with their correspondents at the distant ends, through the synchronized distributor at that point, 34 times in a second. Now while one operator is making the shortest character or letter in the Morse alphabet, which is the letter *e*, consisting as it does of a single dot, let us see what takes place while this single dot is being transmitted. Let us imagine that when the first operator touches his key, and depresses it for the shortest interval of time that he is capable of holding it depressed, the distributor with its trailing finger, which is the end of the line, passes over one of the 12 segments connected to this operator's instrument, and transmits to the other end a portion of this single dot, but does not complete it until the other five operators have been placed in connection with the line, and the second, or third segment of the first operator's circuit has been touched by the trailing finger when the single dot representing the letter *e* is completed. Thus one dot is made up of two, three, or more shorter impulses, which manifest themselves on the polarized relay at the distant end, as one short signal, notwithstanding that portions of letters or characters have been transmitted by five other operators between the time of the beginning and the completion of this single dot. This is an irrefutable evidence of a synchronism that has never before been more than contemplated as but a remote possibility.

The operation of the printing instrument by this system is another illustration of the degree of perfection of Mr. Delany's synchronism, that is hardly less striking than the foregoing; since if seventy-two printing instruments are used, each instrument must be dependent on a single segment for its message, and an instrument at each end of the line being connected to a single segment correspondingly located; the distributor must connect the line with those single segments at precisely the same instant, otherwise no impulse for the indication of a letter on the type wheel will be received. Theoretically it might be supposed that the transmission of a signal, say from Philadelphia to New York, by an instrument connected to a single segment, would not necessarily require that the trailing finger in the New York instrument should be on the corresponding single segment at the time that the signal was sent into the line at the Philadelpia end. Or, that the trailing finger on the New York instrument might be one segment behind the segment corresponding to the segment on which the signal was sent into the line at Philadelphia, and that still that the signal could be received on the corresponding segment in the New York instrument, since the time required for that signal to pass and manifest itself in New York would be sufficient to allow the New York instrument to reach the segment corresponding to the one from which the signal was sent into the line from Philadelphia. The fact that it takes time for the transmission of signals according to the distance and other conditions not necessary to discuss here, no one will dispute it, but, that this time admits of variation of movement or departure from synchronism in Mr. Delany's machine, is disproved by the machines themselves, for, if another instrument be connected to the next adjoining single segment in each machine, and a signal be sent from *New York to Philadelphia* immediately after, or within about the $\frac{1}{500}$ part of a second afterward, the signal from New York is received in Philadelphia as perfectly as that from Philadelphia was received in New York, thus, showing conclusively that the conditions of variation before referred to cannot have existed, since otherwise no signals could be received from New York or Philadelphia, over the second segment, as the Philadelphia instruments would have left the segment before the signal could have been completed on the segment in the New York machine and transmitted to Philadelphia.

Probably the most extraordinary proof of practically absolute synchronism was demonstrated by the experiment recently made by Mr. Delany over the line between Boston and Providence, whereby a single dot was transmitted from Boston to Providence and automically repeated back and forth over the same wire at practically the same instant of time, travelling over different circuits in rotation backward and forward for the duration of five minutes, during which time it traveled four hundred and fifty thousand miles, this time, of course, being almost wholly represented by the movement of the armatures of the instruments. When we consider, however, the conditions involved in the transmission of a single dot, as in the case of the letter *e*, already referred to, the extent of perfection of the synchronism obtained will be understood.

Before concluding, I desire to call your attention to some contemplated applications of the wonderfully complete synchronism of Mr. Delany which he has conveyed to me. Among some of these may be mentioned fac-simile transmissions of the reproduction of signs, characters, or hieroglyphics. For instance, a fac-simile copy of a dispatch, a drawing of a map, or a pen portrait of an individual may be transmitted to any distant point. The prime condition necessary being synchronism; so that the time is probably not far distant when the civil authorities can render the identification of criminals almost certain by having their portraits in the hands of an officer on the arrival of the train upon which the criminal has fled. Or, a newspaper in these days of enterprising journalism, many have transmitted for publication a sketch of a great public disaster or of any other event calling for illustration.

In conclusion, permit me to say that the invention by Mr. Delany of practically complete synchronism would appear to go no little ways towards the solution of a problem that stares practical men so squarely in the face. I allude to the problem as to what shall be done with the electric conductors that are strung over the houses and through the streets of our large cities. Whether these wires are to be placed underground or are to continue overhead, is a problem which in my opinion, is as yet far from being solved. The increased capacity which Mr. Delany has obtained for every wire will, it is clear, greatly decrease the number of wires required for actual use and this makes the problem referred to somewhat easier of solution.

DISCUSSION.

Prof. Houston:—I would say here, however, that Mr. Delany's system is not necessarily dependent upon the phonic wheel, as he has invented a magnetic motor which, when placed in connection with his automatic system of control, is capable of and containing exactly similar effects as are obtained with Lacour's phonic wheel.

Mr. Delany has very recently made an experiment on the telegraph line of the Pennsylvania Rail Road, and has sent messages from Philadelphia to New York and back again to Philadelphia. That was done last Sunday. I don't know how many relays were worked, but it worked successfully on the Pennsylvania lines.

In concluding this paper, I may mention, that I have had some conversation with Mr. Keith as to whether or not it would be advisable to go into a discussion of the means by which Mr. Delany has obtained his synchronism, and we came to the conclusion, that the time available to us is so short, that it would be worth while to go over the description of the means, which we can fairly suppose you are familiar with. Mr. Keith tells me, that when he publishes this paper, he will probably reprint some of the articles that I have written, which contain a full and exact description of the methods employed. Otherwise it would be difficult to compress any description of the system in the space of an hour. I see, very fortunately, that Mr. Delany is here himself, and if there is time, I would suggest, that he be called upon.

The Chairman (Mr. W. D. Sargent):—Mr. Houston has given us a very interesting paper. As I understand, Mr. Delany is here, and our time is limited—but we would be glad to hear from Mr. Delany.

Mr. Delany:—I don't know as I have anything to say, unless some persons, not understanding the theory and principle of synchronism, would like to make inquiries, if so, I would be very glad to respond.

So far as an explanation of the system is concerned, I think it would be much more satisfactory, individually and collectively, if we would go to the exhibition and see the system in operation. There every facility is at hand to make a much clearer explanation as to how it is done, and that certainly would be much more satisfactory than anything I would attempt to do here. However, if any of the gentlemen have anything to inquire about, I would be very glad to enlighten them as far as I can. I take pleasure in extending to the gentlemen of the conference here a cordial invitation to come out and see our system in operation in the exhibition building. We will be there during the week, and when they come, if they will make themselves known, I shall take particular pains to show it to them.

The CHAIRMAN:—Your apparatus in that building is simply working in the building?

Mr. DELANY:—We have no outside facilities at all. On Sunday we worked from Philadelphia to Jersey City and back over the Pennsylvania wires with a No. 9 and a No. 8 wire. One was an old wire, I don't know its electrical condition, it seemed to be in pretty good order.

Mr. MAILLOUX:—You are working through an artificial resistance, are you not?

Mr. DELANY:—Yes, our battery is very limited, consequently we are restricted to a lower resistance. On Sunday we had the Pennsylvania Railroad batteries, so we were able to work through to New York and return.

Mr. KINTNER:—What is the longest circuit you have worked?

Mr. DELANY:—We worked a year ago over the American Rapid Line from Boston to New York. We had then only progressed as far as the quadruplex.

Mr. KINTNER:—Do you find any static trouble over that distance?

Mr. DELANY:—There we had static trouble, but they were overcome.

Mr. KINTNER:—By ground contacts?

MR. DELANY:—Ground contacts. This was entirely practical The ground contacts afforded us a mechanical remedy for getting rid of the static troubles within our reach. For a longer distance, it would only be necessary to make the ground contacts a little larger.

Mr. KINTNER;—I was thinking of that.

Mr. DELANY:—Or larger than the contact connected with the operators' instruments. Of course such an enlargement would to a certain extent be at the expense of the operator's contact. If we have ground contact about the same size, so the line will have the same duration with the ground that it had with the operator's instrument we can work very satisfactorily. The circuit referred to was 250 miles over a No. 8 galvanized iron wire. If it is necessary to work further over that kind of a wire we will probably have to put in repeaters or use a copper wire.

Mr. **Kintner**:—Have you ever tried the condenser?

Mr. **Delany**:—We could not use that very well, we could not apply the condenser, because our currents are constantly being reversed. We use polarized relays. So while it would assist in one instance, it would create a difficulty in the other.

Mr. **Kintner**:—I had forgotten about the polarization.

Mr. **Delany**:—We have worked successfully through three repeaters, and have worked through five; it was simply only necessary that the sounder of one circuit should become the transmitter in another circuit.

The **Chairman**:—To what extent is your system dependent upon the electrical condition of the conductor between the two ends?

Mr. **Delany**:—We have but very little difficulty from that cause. Synchronism is maintained, if we get sufficient current over the line to actuate the armature of the correcting relay adjusted in the most sensitive way, the armature of the electromagnet is adjusted by a delicate spring, so as to keep the armature against the back stop. If we get a sufficient current over the line to move the armature from the back stop, we can synchronize. In fact we can synchronize further than we can telegraph. Any ordinary change in the condition of the line does not affect us at all, because frequently we have put three or four thousand ohms of resistance into the line, and taken it out suddenly without affecting our synchronizing apparatus. With polarized relays and reversed current a fluctuating condition of the line does not affect us as it would an ordinary relay. It is simply a question whether you get sufficient current over the line to actuate the most sensitively adjusted relay. As long as we can do that we can work.

Mr. **Maynard**:—Is it possible for these machines to get out of synchronism?

Mr. **Delany**:—Oh, yes.

Mr. **Maynard**:—What do you do then?

Mr. **Delany**:—They come in of themselves, if you let them alone within themselves two minutes. The correcting impulses sent over the line will correct a discrepancy in vibration of the forks of about five vibrations per second. If you should open a wire between the two stations, the instrument would then have to run independently, they would get out of synchronism within a minute or two. The instrument may be locked up and not be accessible to anybody. If they should be thrown out of synchronism they would come to that point again of themselves.

Mr. **Mailloux**:—Do you maintain the line of circuit so they can keep themselves in a synchronal condition.

Mr. **Delaney**:—Oh, yes; the line of circuit is always closed, subject to interruptions, of course, of the commutator from the circuit table.

Mr. **Mailloux**:—I mean when the operator wishes to send a message in the ordinary way, he does not have to wait until the line is synchronized.

Mr. **Delany**:—He has to wait until the line is synchronized to send the message; if he did not, the message would not reach the operators in connection with that circuit at the distant end.

Mr. **Mailloux**.—When the machine is in use on the line, I wish to inquire whether the machine is maintained in a synchronized condition?

Mr. **Delany**:—It is always maintained in a synchronized condition. Each operator's instrument is always to the ground, so that if the operator at the other end of the line closes his key, it is manifested directly to the corresponding operator at the distant end.

Mr. **Mailloux**:—It is your purpose, is it not, to maintain that local circuit in action all the time, so that the phonic wheel is moving all the time at either end?

Mr. **Delany**:—Always; at night we shut them down if there is no longer necessity for running them.

Mr. **Mailloux**:—You open in the morning and synchronize?

Mr. **Delany**:—After we start them in the morning they run all day.

Mr. **Mailloux**:—With the ordinary Morse system how many transmissions can be made practically and profitably over one wire.

Mr. **Delany**:—We make six transmissions by the Morse at the highest rate of the ability of the operator. That is, you can send forty words per minute — we have transmitted from Providence to Boston, and Boston to Providence and back to Boston by a line, which I suppose is a circuit of about 100 miles, very close to 1000 words on the sixth of a wire, *i. e.*, when the wire was distributed sextuplex at the rate of from 43 to 44 words per minute. I received myself over a twelfth of a wire on eleven hundred words at an average of twenty words and a fraction. It is equal to 18 or 20 words beyond a doubt. Now as to the commercial advantages of either the six or twelve divisions of the segments that is a question. For the commercial telegraphy I suppose that between two offices doing an ordinary telegraph business, the six circuits could be worked to the best advantage, because it requires the less number of operators to the circuit, and each circuit is equal to the best ability of the most expert operator. But for renting purposes, you may rent twelve circuits to a greater advantage than the six; beyond the twelve we have to abandon the Morse system and use Printers.

were close to 2000 words in the space of [illegible] when the circuit was [illegible] complete at the rate of from 40 to 44 words per minute. I received myself over a circuit of [illegible] on eleven thousand words at an average of [illegible] words and a fraction. It is equal to [illegible] words beyond a [illegible] day as to the commercial advantages of either the Morse or the [illegible] of the [illegible] that is a question. For the commercial [illegible] I suppose that between two offices doing an ordinary [illegible] business, the six circuits could be worked to the best advantage, because it requires the [illegible] of operators to the circuit, and each circuit is equal to the best ability of the most expert operator. But for [illegible] purposes, [illegible] should [illegible] greater advantage [illegible] beyond [illegible], we have to abandon the Morse system and use Printers.

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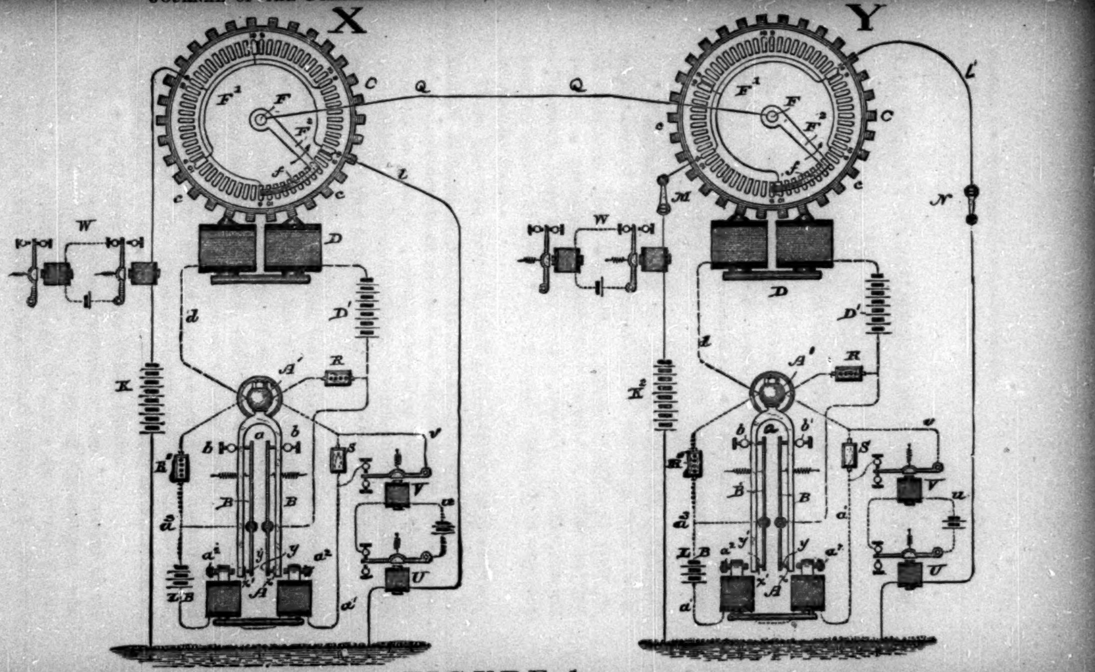
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FIGURE 1.

Reprinted from the Journal of the Franklin Institute.

THE DELANY SYNCHRONOUS-MULTIPLEX SYSTEM OF TELEGRAPHY.

By Prof. Edwin J. Houston.

In this day of remarkable advance in electrical science, it is necessary for an invention to possess very unusual practical applications, and to display uncommon ingenuity or genius on the part of the inventor, to attract any more than transient attention or admiration on the part of the general public.

The successful laying of the Atlantic Cable, the commercial applications of electric illumination, and the actual transmission of telephonic dispatches, have very properly given to their inventors or promoters a world-wide reputation. The rapidity with which these inventions have followed one another, has led many to believe that but little new could reasonably be expected in the near future.

There has been, however, during the past two or three years, another inventor at work, who has at last completed, even to many minor details, an invention which, if we are not mistaken, bids fair to rival in importance anything that has hitherto been accomplished in electrical science; we refer to the system of synchronous-multiplex telegraphy, of Mr. Patrick B. Delany, of the city of New York.

Like other great inventions, that belong rather to eras than to individuals, the growth of the synchronous-multiplex system has not been entirely the product of any single mind; though, in this particular instance, too much credit can scarcely be given to Mr. Delany, to whom the practical or working part of the system is almost wholly due. Indeed, since this gentleman has introduced into the system the numerous details and separate inventions, without which its commercial application would be impossible, we may correctly speak of it as the Delany system.

The Delany synchronous-multiplex system is founded on the Phonic Wheel of Mr. Poul La Cour, of Copenhagen, who patented his invention in Great Britain, under Letters Patent, No. 1,983, of 1878; and in the United States, as No. 203,423, of May 7, 1878.

Before proceeding to the description of the detailed apparatus of this remarkable invention, it will be best to first explain the nature of the work for which it is applicable, and to point out some of the more evident directions in which it may be practically employed.

The most evident commercial application of this system is its use for transmitting simultaneously, over a single wire, a great number of telegraphic dispatches, either in the same or in opposite directions.

Before the invention of the synchronous-multiplex system, the greatest number of messages that could be transmitted simultaneously over a single wire, as in the well-known quadruplex system, was four; and in this case, the four messages were, of necessity, sent in opposite directions; viz., two in one direction, and the remaining two in the opposite direction. In the synchronous-multiplex system, not only is the number of messages that can be transmitted greatly increased, but all such messages can be transmitted in one and the same direction; or any desired number sent in opposite directions. The great commercial importance of this feature of the invention will be at once recognized.

It may not be out of place to mention in this connection, as a confirmation of the importance of any system that will permit the simultaneous transmission of more than a single dispatch over the same wire, that it is a well-attested fact that the Western Union Telegraph Company has been enabled, to a very great extent, to practically control the telegraph business of the United States, by reason of its owning or controlling the only method heretofore known for successfully accomplishing this object.

Though we have mentioned the quadruplex as being the only system hitherto commercially employed for multiple transmission of dispatches, we have not forgotten the harmonic system of Mr. Gray. This, however, we believe, has not been commercially introduced to any considerable extent, owing to certain inherent difficulties attending its practical use.

Perhaps one of the most prominent features of the multiplex-synchronous system is its marked dissimilarity from either the quadruplex or the harmonic systems, already mentioned. The multiplex is a new departure in telegraphy, now practically realized for the first time.

As is well known to those acquainted with the principles of electro-magnetic telegraphy, the quadruplex system is based on the balancing or differential method, whereby the instrument of the transmitting operator, being unaffected by the signals he transmits, is thus left open for the reception of signals sent from the distant end of the line.

The synchronous-multiplex system, on the contrary, is based on the synchronous rotation of two discs, placed one at each end of the line, by means of which a single wire, which constitutes the line, is simultaneously connected, at both of its ends, to corresponding operating instruments, and transferred from one set of instruments to another so rapidly that the operators, either sending or receiving, cannot realize that the line has been disconnected from their instruments and given to others, because each of them will always have the line ready for use, even at the highest rate of manipulation, and will, therefore, to all practical intents and purposes, have at his disposal a private wire between himself and the operator with whom he is in communication.

It will be seen, therefore, that in the synchronous-multiplex system, although more than one operator may be spoken of as simultaneously using the line at any given time, yet, in point of fact, no two operators are in reality absolutely using it at the same time; but that they follow one another at such short intervals, and the line is taken from one operator and transferred to another so rapidly, that none of them can at any time tell but that he has the line alone, and that therefore it is practically open for the use of every operator just as if he alone had control of it.

There will be practically established, by the use of a single line, as many private and separate lines as there are transferences of the line from the time it is taken from the first operator, and again given back to him.

This has, as we will hereafter point out, been extended in actual practice to as many as seventy-two distinct and separate circuits, maintained and operated on a single connecting wire.

It will be readily understood that the rapidity of transmission of each telegraphic dispatch will be necessarily diminished as the number of messages that are simultaneously transmitted is increased. This decrease in the rate of transmission, however, is far less than might be supposed necessary, as actual experience has abundantly demonstrated. For example, with the simultaneous use of six Morse telegraphic circuits, the most rapid rate of transmission attainable by the most expert operators is practicable; and with twelve Morse circuits, a rate of transmission is practicable as rapid as that generally employed by the ordinary operator; that is, by an operator whose rate of sending would be regarded as equal to that actually employed by the greatest number. It must not be supposed, however, that the use of the multiplex-synchronous system will be limited to the simultaneous transmission of twelve separate messages on one and the same wire, since certain contemplated improvements will, it is confidently believed, greatly increase both the rate of transmission and the extent of division of the line.

There have been actually applied to a single line, as we have already mentioned, as many as seventy-two separate and independent circuits. In this case, the Morse instruments have been replaced by the ordinary printing telegraphic instruments, so that the messages are received and recorded on paper slips, in the well-known manner as practiced in the stock printing instruments.

Although the rate of transmission is, in the above case, considerably decreased, yet the adoption of a printing instrument is attended with many advantages that go far towards removing the slight inconveniences that result in actual commercial use. A printing instrument, as is well known, requires no special skill on the part of the one who operates it. Any one who can spell can transmit a telegraphic dispatch, while no operator need be on hand for its reception, since the receiving instrument is entirely under the control of the person sending the dispatch. The necessity for skilled operators at each end of the line is, therefore, in a manner entirely done away with.

Three very considerable advantages are obtained by employing printing instruments, and thus doing away with the services of skilled operators for sending and receiving the dispatches, viz.: economy, secrecy, and an increase in the number of messages that can be sent during any given time.

The advantages on the score of economy and secrecy are manifest. Not only is the skill of an operator required at each end of a private line employing Morse instruments, but, since private messages are to be transmitted thereon, integrity, as well as skill, is a prime essential, and both of these requisites must be paid for. On private lines, maintained by the use of the synchronous-multiplex system and printing instruments, no publicity is necessary, the interested parties only, sending and receiving the dispatches.

The advantages on the score of rapidity, arising from no operator being needed at the receiving station, when printing instruments are employed on a private line, lie in the fact that the line being a private one, no time is lost in waiting for some other party that may be using it, nor in calling the party for whom the dispatch is designed, or in waiting for his return, during a temporary absence.

Taking all these facts into consideration, we think it will be found in actual practice, that the decrease in the rapidity of transmission, consequent on the simultaneous employment of seventy-two separate circuits on one and the same line, is not sufficiently great to interfere, to any marked degree, with its commercial applications. In point of fact, with the system as it is now actually used, the rate of transmission is quite sufficient to enable each of the seventy-two subscribers or users of the line to transmit, during, say, the six hours that elapse between 10 A. M. and 4 P. M., the business hours of the day, no less than one hundred telegraphic dispatches of the ordinary length, an amount generally in excess of actual requirements of ordinary business, and, as a rule, quite in excess of any rate of service that could be reasonably expected on the part of any of the telegraphic companies on which the general public are now dependent.

An advantage, however, of peculiar importance to the business public generally, that is possessed by the synchronous-multiplex system alone, is the readiness with which a single wire between any two subscribers connected therewith can be increased in its capacity to meet the growing needs for an increased extent of division, or to meet some unforeseen or unexpected emergency. Thus, suppose that one subscriber has a private line placed at his disposal between any two distant cities, and is furnished with what we may term one seventy-second of the line; should his business increase, it would be a matter of simple connection of the transmitting and receiving instruments at the ends of the line to give him increased facilities for communication by placing at his disposal the one thirty-sixth, or the one-eighteenth, and so increase his capacity for communication twice or four times, respectively. In other systems, as is well known, this would need the erection of extra lines, and would necessitate the expenditure of both time and money, so that sudden and unexpected calls for increased facilities for business, which are liable to occur in times of financial crises, or of other great public excitement, could not be met.

A peculiar feature of the synchronous-multiplex system, that is not possessed by any other known telegraphic system, and that cannot fail to commend this system to the general public, is in its absolute secrecy. Unlike other systems, its lines cannot be secretly tapped and the messages intercepted, since an ordinary instrument placed in a break in the line would receive, in an utterly unintelligible form, not only all the signals being transmitted at the time, but also each of the separate makes and breaks in the continuity of the line circuit, while it is successively transferred from one operator to another, and these signals would be so transposed and altered, that even if the instrument could record them, they would be as devoid of intelligent connection as would the type correctly set for numerous messages, and afterwards dropped through successive sieves from a height to the ground. This feature of absolute secrecy of the synchronous-multiplex system will, it is believed, prove of almost inestimable advantage to a government for the secret transmission of dispatches during war, or, in fact, at any time.

The successful operation of the synchronous-multiplex system is dependent on the maintenance of the synchronous movements of the rotating discs placed at the ends of the line. We will now proceed to describe the details of the very ingenious and beautiful contrivances whereby Mr. Delany has practically created a new system of telegraphy.

Fig. 1 represents a diagrammatic plan of two distant stations, say, New York and Philadelphia, or Philadelphia and Chicago, represented by *X* and *Y*, respectively, electrically connected by the single line wire *Q Q*. The connections of the detailed apparatus required at both the transmitting and receiving stations are also shown in the figure.

In the following description the author has not hesitated to freely employ the language of the various patent specifications in all cases where he has deemed it advisable so to do.

An inspection of Fig. 1 will show that the apparatus at each end of the line, at the stations *X* and *Y*, is substantially identical. A steel fork *a*, at each station, is automatically and continuously vibrated by the action of the local battery *L B* and the electro-magnet *A*. The circuit of the local battery is marked in the drawing a^1. The cores of the magnet *A*, which may be called the vibrator magnet, are prolonged in the direction of the free ends of the vibrating fork by the regulable screws a^2, of magnetic material, in the manner shown in the figure. The object of this adjustment of the extended magnet poles is to enable the said poles to be approached towards, or withdrawn from, the tines of the vibrating fork, so as to regulate with great nicety the rate of their vibration.

Platinum contacts x x^1, are placed on the inner faces of the tines of the fork, and make and break contact with delicate platinum contact springs y, y^1 supported by adjustable insulated arms or levers B, B^1, pivoted on the bed-plate of the apparatus. The adjustment of these levers is secured by the thumb-screws b, b^1, against which they are drawn by the action of spiral springs. By these means the platinum contact-springs, y y^1, are readily adjusted with great delicacy and firmness to the platinum contacts x, x^1 on the tines of the fork.

The circuit of the local battery L B, which is indicated in the drawing by the fine dotted lines, runs from the positive pole of the battery, through the coils of the vibrator magnet A, to the head of the fork, and through the contacts x^1, y^1 to the insulated lever B^1, from whence it passes back to the opposite pole of the battery. In order to prevent injurious sparking of the contacts x^1 and y^1, a resistance coil R^1 is placed in a shunt circuit around them, extending from the point a^3 to the head of the fork, and to the insulated arm B^1, as shown.

The fork being mechanically started into a vibratory motion, will automatically make and break its local circuit, and thus send impulses into the fork-magnet A that will continuously maintain the vibrations of the fork, in a well-known manner.

These movements, it will be observed, have been maintained solely by the making and breaking of the contacts x^1 and y^1.

And now for the contacts x and y, which, as we have seen, are placed in connection with the opposite tine of the fork. The making and breaking of these contacts, consequent on the fork's vibration, opens and closes the circuit of another local battery, in which is placed an electro-magnet D, the function of which is to maintain the continuous rotation of the transmission apparatus C.

This circuit, which we will call the motor circuit, and which is indicated in the drawing by the larger dotted lines, passes from the positive pole of the motor battery D^1 to the lever B, through the platinum contacts y and x, to the tine of the fork, to its head or support A^1, and thence through the wire d to the coils of the motor magnet D, and back to the opposite pole of the battery. A resistance *R*, placed in a shunt between the head or support of the fork and the line of the lever *B*, prevents injurious sparking between the platinum contacts *x* and *y*.

As the continuous vibration of the fork is automatically maintained by the local battery *L B*, as already explained, it will, at each vibration, make and break the contacts at *x* and *y*, and thereby make and break the motor circuit. The alternate magnetization and demagnetization of the cores of the motor magnet *D* causes the rotation of the transmission apparatus *C*. The cores of the magnet *D* have their faces shaped so as to conform to the circumference of the apparatus *C*, the teeth of which pass in close proximity to the faces of the curved magnet poles.

The motor magnet and transmission wheel, or disc, *C*, provided with projections *c*, *c*, is the invention of Poul La Cour, already referred to, and is styled by him "phonic wheel."

The transmission apparatus is illustrated in detail in Figs. 2 and 3. As we have already seen, it is an exact counterpart of the receiving apparatus at the other end of the line. A base plate *E*, provided with binding posts for electrical connections, carries a vertical rotary shaft *F*, that has its lower bearing in the bed-plate, and its upper bearing in a suitably supported bridge E^1. A circular table F^1, provided with a series of insulated contacts, is arranged symmetrically around the axis of rotation of the shaft. A radial arm F^2 projects from the shaft *F*, and

Fig. 2.

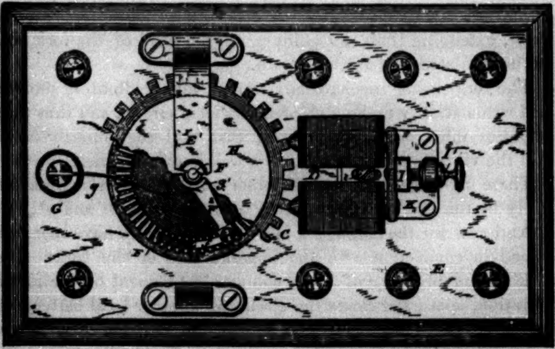
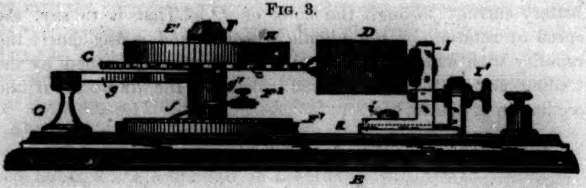


FIG. 3.



carries at its outer extremity a socket and set screw, to which is attached a trailing contact finger f. As the disc C is rotated by the electro-magnet D, the trailing contact f sweeps around the circular table F^1, and is brought successively into contact with the insulated contact pieces placed on the upper face of the table F^1.

The main line Q Q has one of its ends connected with the trailing finger f, through the radial arm F^2, vertical shaft F, contact spring-arm g, and projecting post G. As the shaft F rotates, the line is, therefore, brought into successive electrical connection with the series of insulated contacts in the upper face of the table F^1. The toothed armature, or phonic wheel, C is securely keyed to the vertical shaft, F just above the hub g^1.

In order to equalize the speed of rotation of the apparatus, a cylindrical vase H, of wood, or other suitable material, filled with mercury, is attached to the face of the phonic wheel C, and rotates with it.

The cores of the motor magnet D, suitably supported by the standard I, can be readily adjusted towards, or from, the armature teeth on the phonic wheel C, by the motion of a screw I^1, which moves the standard I in an elongated guide slot, through which passes the screw bolt i.

The cause of the synchronous rotation of the phonic wheel C is substantially as follows, viz.: Considering the action of a single pole of D when the wheel C is at rest, that one of its teeth, or projections, c that is nearest the pole of D will be attracted towards it, and maintained in position nearest it, by the influence of the magnetic attraction of the pole of D; should, however, the phonic wheel be set into motion, with a velocity that shall cause a tooth c to pass the pole D for each intermittent impulse in the battery circuit traversing the coils of D, the wheel will be maintained in a rotation, the speed of which will be regulated and controlled by the frequency of intermissions of the battery current through the coils of *D*. That is to say, the speed of rotation of the phonic wheel *C*, and consequently the rapidity with which the successive contacts are reached by the trailing arm F^1, are regulated solely by the duration of the oscillation of the fork *a*.

Fig. 4.

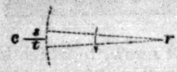


Fig. 5.

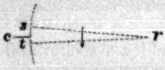
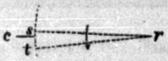


Fig. 6.



The control which the intermission in the circuit traversing the coils of the electro-magnet *D* exercises on the regularity of rotation of the phonic wheel *C*, will be better understood from an inspection of Figs. 4, 5, and 6.

Suppose that the central or axial line of the pole of the magnet *c* is represented by the dash placed opposite *c* in the figure, and that *r* indicates the centre of the phonic wheel *C*, whose direction of rotation is indicated by the arrow. Now, if during one impulse, the central or axial line of one of the magnet teeth *c* on the phonic wheel is moved from the point *s* to *t*, it will be accelerated on its way from *s* to *c*, but retarded from *c* to *t*.

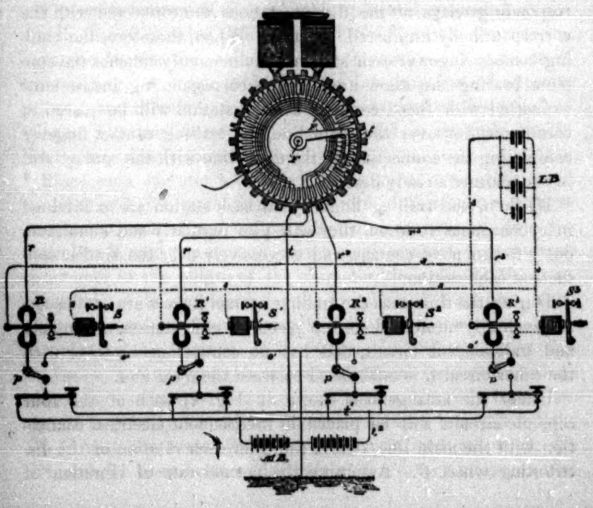
If, then, as shown in Fig. 4, the acceleration and retardation are equal, the velocity of the wheel is unaffected by the impetus of the electro-magnet; but, should the wheel move slower, that is, lose in its motion, as shown in Fig. 5, then the acceleration *s*, *c* will increase, and the retardation *c*, *t* will decrease. Consequently, the electro-magnet *D* will increase the velocity of the wheel in the same ratio that the wheel slows, or loses time.

If, however, the wheel gains or increases in speed, as shown in Fig. 6, the acceleration *s*, *c* will be decreased, and the retardation *c*, *t* increased, so that the electro-magnet will have the opposite effect, and retard the wheel, in the same ratio that it tends to increase or go faster.

In the apparatus for transmission and reception, shown in connection with Fig. 1, which is substantially the same as that just described, the table of contacts F^1 is, for convenience of illustration, shown as placed above the armature disc *C*. In starting the disc *C*, an impulse of rotation is given to it somewhat in excess of the speed at which it will be maintained by the motor magnet, when, as the speed of rotation decreases, the armature teeth will come into proper relation with the poles of the magnet, and into the periods at which the makes and breaks occur in the circuit traversing its coils, when the disc will be continuously driven by the motor magnet. A suitable thumb-piece, placed on the vertical axis F^1, serves to start the apparatus, an operation that is readily accomplished after very little practice.

Any suitable number of insulated contacts may be placed on the circular table F^1; sixty are shown in the figure. In practice these contacts are connected in accordance with the special number of circuits which it is desired to simultaneously maintain on the same wire. In the special case shown in connection with Fig. 7, it is arranged so that four separate circuits shall be established on the same line wire. The sixty contacts are placed in six independent series, numbered from 1 to 10, consecutively. In the arrangement here shown, two of the contact pieces in each series of ten are connected in the same circuit, and as there are six series, each of the circuits so connected will have twelve contacts for each rotation of the disc. An inspection of Fig. 7 will show that the 1's and the 5's in each series are all connected in one and the same circuit; the 2's and the 6's in another circuit; the 3's and the 7's in another circuit; and the 4's and the 8's in another

FIG. 7.



circuit—thus providing four separate circuits, in all. The contacts, therefore, from one to eight in each series, are apportioned among the four independent circuits, each of which will receive, for each revolution of the trailing finger, twelve contacts and twelve electrical impulses, as will be afterwards described.

The detailed mechanism, by means of which the separate and independent circuits so obtained are utilized for the transmission and reception of messages, is shown in connection with Fig. 7. R, R^1, R^2, and R^3 are polarized relays, the function of which will be afterwards explained. S, S^1, S^2, and S^3 are ordinary Morse sounders, although in the practice of this invention some improvement has been introduced in connection with the instrument. The connections with the main and local batteries M B and L B are clearly shown in the figure.

It will be noticed that the relay R is connected by the wire r with the contacts 1 and 5; R^1 is connected by r^1 with the contacts 2 and 6; R^2 by the wire r^2 with the contacts 3 and 7; and R^3 by the wire r^3 with the contacts 4 and 8. Similar instruments and circuits are placed at each end of the line.

Without further describing the operation of the instruments shown in Fig. 7, it need only now be borne in mind that the corresponding relays at the distant stations are connected with the correspondingly numbered contacts. When, therefore, the trailing contact finger at each station simultaneously touches the contacts bearing the same number, the corresponding instruments connected with these contacts at each station will be placed in communication over the main line, the trailing contact finger f completing the connection of the main line with the contact arm in the manner already described.

If, then, the trailing fingers f at each station are maintained in synchronous rotation, they will pass regularly and simultaneously to the next contact, and successively over the similar contacts at each station.

During the time that the trailing contact fingers are on the correspondingly numbered contact pieces at each station, a complete and independent circuit, that has no connection whatever with the other circuits, is established between these stations.

Under the arrangement shown in Fig. 7, each of the four separate circuits will be placed in independent electrical connection with the main line, twelve times for each rotation of the distributing wheel C. Assuming the normal rate of vibration of the fork at eighty-five vibrations per second, and that the distributing wheel *C* is furnished with thirty armature teeth, or polar projections, the armature discs and trailing fingers will be rotated at the rate of two and five-sixths times per second, so that the corresponding instruments at the two stations will be placed in independent electrical communication with the main line, thirty-four times each second. This number of contacts per second will give to each set of operators a practically unbroken circuit, so that the operators at any two connected stations may communicate with each other, in either direction, as if they had a separate and independent line devoted entirely to their exclusive use.

We will now describe, in greater detail, the method adopted for transmitting and receiving the messages over any, or all, of the four circuits so provided. An inspection of Fig. 7 shows the relays R, R^1, R^2, and R^3 connected with the series of contacts, as described, and the circuit completed from each relay, either to the ground through the line o^1, when the switches p are placed as at R^1 and R^3, on their upper contacts, when the line is ready for receiving; or in connection with their lower contacts, as at R and R^2, when the line is ready for transmitting.

The main battery *M B*, preferably split and grounded in the middle, has its positive pole connected with the back stops of the keys, and its negative pole with their front stops. The action of transmitting, therefore, sends into the line impulses of opposite polarity, and therefore permits the employment of the polarized relays. The local battery *L B* is connected in multiple arc, in the manner clearly shown in the drawing.

Since each operator's circuit is made up of numerous rapid contacts with the main line, at the rate of thirty-four contacts per second, each of the ordinary Morse characters sent into the main line is made up of more than a single contact, proportioned in number to the length of the character, the ordinary Morse relay could not be employed for the reception of these characters, since the numerous breaks comprised in each character would be recorded by the armature of the relay. In order to avoid this confusion, and to make the relays respond not to mere pulsations caused by the successive makes and breaks, but only to the reversals in polarity, caused by the connection of the split battery *M B* with the transmitting keys, the polarized relays R, R^1, R^2, and R^3 have been used in place of ordinary relays, so that the armatures of the polarized relays remain in the position that the last current has placed them, until reversal of the current changes their position, notwithstanding that the finer vibrations comprised in these reversals are continuously passing through the magnet of the polarized relay, but are not manifested on the armature. This feature of the invention is due to Mr. E. A. Calahan, the inventor of the gold and stock printing telegraph, and also the inventor of the American District Telegraph System, and who has been associated with Mr. Delany from the commencement of his investigations on the subject, and whose ability and great mechanical skill have very materially aided the full development of the system.

The prime essential for the successful application of the preceding system is undoubtedly the maintenance of the synchronous movements of the trailing arms over the contact pieces on the table F^1. This Mr. Delany has effected by an invention of marvelous beauty and ingenuity, which is entirely automatic in its operation, and is so successful in practice that the synchronism can be perfectly maintained for days continuously without one instrument varying from the other the six-hundredth part of a second during that time. We will now proceed to an explanation of the comparatively simple means by which this practically absolute synchronism is maintained.

It has been shown, in connection with the description of the operation of the transmitting wheel, that its rate of motion is absolutely controlled by the rate of vibration of the fork, by means of which the successive impulses of the battery current through the motor magnet are regulated.

Now, it has been tried, but unsuccessfully, to obtain this synchronism by the mere mechanical adjustments of two forks, one at each end of the line; the forks being delicately tuned to exact unison with one another.

The many circumstances which produce slight variations in the rate of vibrations of a fork, have rendered it impossible to maintain, even in the same room, synchronism between two forks for more than a few minutes at a time, and this has only been possible by the most careful attention to the adjustment of the same. At distant stations, where the mere differences of temperature alone would, of necessity, produce sensible variations in the rates of motion of the two forks, the maintenance of even approximate synchronism would be practically impossible.

Mr. Delany has completely overcome this hitherto insuperable obstacle to the successful adoption of any synchronous-multiplex system, by the happy invention of correcting impulses, that are automatically sent over the main line from one instrument to another, at such times only as the distant instrument is slightly in advance or behind the other instrument. These correcting impulses, that are thrown into the line only when needed, and of the necessity for which the instruments themselves, so to speak, are constituted the judges, are utilized for the purpose of slightly increasing or decreasing the rate of vibration of the distant fork, and, consequently, the rate of rotation for the trailing arm at the distant station.

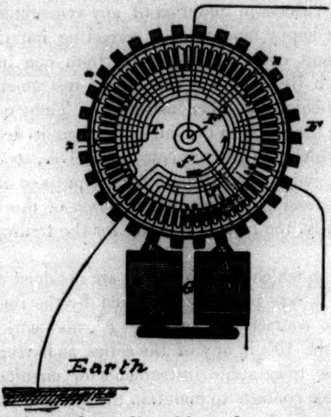
The manner in which these impulses are obtained when needed is as follows: It was probably remarked by the reader, that in speaking of the contacts in the plate F^1, no mention was made of the 9's and the 10's in any of the series, as having connection with any of the telegraphic instruments or circuits. It is the function of these contacts to maintain the synchronism of the apparatus.

Referring again to Fig. 1, it will be noticed that at one of the stations, as *X*, three of the 9's, that are the furthest removed from one another, that is, three that are 120° distant from each other, are connected together, and to a battery *K*, one pole of which is connected to the ground; and that three of the 10's, that are likewise furthest removed from one another, are connected together and to a line *l*, leading to the correcting and regulating devices, which we will afterwards describe. The remaining three intermediate 9's and 10's are left open, that is, are not connected with any circuit.

At the other station, *Y*, the 9's, corresponding with those connected with the battery at *X*, are left unconnected, or open, while the alternate 9's are connected with the battery K^2, one end of which is grounded, while the 10's, at *Y*, which are connected with one another, and with the connecting devices through the line l^1, correspond with those which are unconnected with the station *X*, the remaining 10's, at *Y*, being unconnected at both stations; the three 10's, which are connected with the correcting devices through the lines *l* and l^1, respectively, are extended or built out towards the adjoining 9's, that are unconnected with any circuit.

In order to provide room on the table F^1 for the expanded

FIG. 8.



or extended 10's, without disturbing the symmetrical arrangement of the remaining contacts, the plates or contacts provided for the static discharge of the line, and which an inspection of Fig. 8 will show, as located between each of the successive contacts of the circular table F^1, are omitted, and their place occupied by the extension of the expanded 10's, so that the space between the expanded 10's and the 9's which precede them is the same as the spaces between the remaining contacts. Since the 9's preceding the extended 10's, and corresponding in position to the battery-connected 9's, are open or disconnected, and since the static discharge plate between the 9's and the 10's at the distant end is retained, no bad results are experienced.

As long as the trailing contact fingers are moving synchronously at both stations, that is, as long as they rest on correspondingly numbered contacts at the same moment, no occasion will exist for the correction of either apparatus; should, however, the instrument at *Y* run a trifle faster than that at *X*, the trailing finger *f*, at station *Y*, will touch the extended side of a 10 contact, while the finger at *X* is still on a battery-connected 9. An electrical impulse, consequently, will flow from the battery *K*, at station *X*, over the main line, and through the contact 10, at *Y*, and the line, l^1, to the connecting device at that station.

A similar operation occurs if the apparatus at *X* moves a trifle faster than that at *Y*.

As thus arranged, the correcting impulses are retarding ones, since they are called into action only when the instrument at one or the other end of the line gains in speed slightly on the other. The inventor causes them to act as retarding impulses by employing them to cut a resistance out of the circuit of the vibrator battery. The effect of this is to increase the strength of the current traversing the coils of the electro-magnet *A*, and consequently its magnetic attraction for the tines of the fork. There thus results an increased amplitude of the fork's vibration, and a consequent lowering, or decrease, in the rapidity of its vibration. This retardation will, of course, affect the speed with which the transmission wheel is rotated, and consequently retard the rotation of the trailing finger.

The local circuit of the vibrator is shown in Fig. 1 as working generally through the adjustable resistances *S*. When, however, the apparatus at one station runs slightly in advance of that at the other station, and a correcting impulse is consequently received through the main line and the line *l*, or l^1, the relay *U*, placed in that line, is energized, and its armature drawn from its back stop, thus breaking the local circuit *u*, and permitting the armature of a second electro-magnet *V* to rapidly pass to its back stop, and thus complete a shunt circuit *v* around the resistance *S*, so as to cut it out of the vibrator circuit. The consequent increase in the current strength of the vibrator circuit that is thus momentarily produced, retards the rate of vibration of the fork, and consequently slows the rotation of the trailing finger, and causes it to drop back on its proper contact. The operation is the same at both stations.

Whenever the operator at either station hears the stroke of the relay *V*, he knows that a correcting impulse has been received. By placing a relay and sounder *W* in the circuit of the correcting battery, at each station, between the 9 contacts and the ground, he can also tell when a correcting impulse has been sent out. No difficulty will be experienced, therefore, in ascertaining which of the instruments is slightly in advance of the other, but as long as any ticks or sounds are heard on the instruments on the correcting circuits, the instruments will be found to be in synchronism, since the variations possible are confined to a limit not exceeding one-fifth of the width of any regular segment.

The apparatus is readily started by starting the fork and rotating the vertical shaft *F*, and the adjustment of the two apparatuses is completed at the other station *Y*. At that station the operator also starts his apparatus and closes the switches at *M* and *N*. By the means already described the operator at *Y* can tell which apparatus is running the faster, and he then proceeds to adjust his own apparatus, until he is aware of the synchronism of the two, by the tell-tale strokes at *V* and *W*. It is found convenient in practice to make the resistance at *S* in the shape of a box of resistances, so as to readily vary the amount of resistance normally included in the local circuit.

A very important and beautiful feature of this invention is found in the manner in which the correcting impulses are rendered effective when the relay *U* leaves its back stop, as the corrections are thereby rendered practically instantaneous; whereas, if they were not made effective until the armature of the relay had been drawn to its front stop, the action of the correcting device would be sluggish. The adjustment of the armature of the relay *U* is very delicate, and it therefore responds immediately to any correcting impulse; so, too, the spring of the relay *V* is of sufficiently high tension to enable its armature to move almost instantaneously to its back stop.

Should the trailing arm at one station be moving more rapidly than that at the other station, it must soon overtake the trailing arm at the other station and bring them both into such relation to the battery connected 9's, and the extended correcting 10's, that the correcting impulses will thereafter maintain them in practical synchronism.

Should the main line between the two stations be accidentally broken, the synchronism would of course be destroyed; but on connecting it again, the instruments would of themselves, within two or three minutes at the most, again come into synchronism without the intervention of the operators.

The correcting impulses we have described are retarding ones, and are only called into play when one instrument runs faster than the other. Mr. Delany has slightly modified his apparatus, so as to make the correcting impulses accelerating ones, that are only called into play when one instrument runs slower than the other.

In this connection it may be well to state that numerous devices by means of which synchronism can be obtained, in connection with substantially the apparatus before described, have been discovered by Mr. Delany, and are fully protected.

We have described four sets of independent circuits simultaneously established on the same line. It is evident, however, that by increasing the speed of rotation, fewer contacts during a single rotation will suffice for the practical operation of the ordinary Morse circuits, or by increasing the number of contacts in the circle, a much greater number of circuits may be obtained, so that the subdivision of the line into a greater number of circuits may be effected, without diminishing the speed of working.

An essential feature of the invention, without which it cannot be practically operated for long distances, consists in separate contacts, as shown in Fig. 8, placed between the contacts on the table F^1, at each station, and connected together to the ground, so that the line, being put to the ground before each completion of the circuits, will be freed from the greater or less static charge, which is very apt to be present in all lines of any considerable length.

Though the synchronous-multiplex system, as we have seen, is somewhat complicated in its apparatus, it is far simpler in its operation, and requires far less delicate adjustments than are essential in the quadruplex system. The difference between the two in this respect will better appear, when it is known that in the quadruplex system a change of electrical condition, equivalent to an increase in the length of the circuit of ten miles, is sufficient to throw it out of balance, and thus stop all communication; while in the synchronous-multiplex system, a change equivalent to five hundred miles may be instantly thrown on the synchronously operated wire without destroying the synchronous rotation of the trailing arms, or interrupting the various circuits.

The possibilities that suggest themselves as naturally resulting from the solution that Mr. Delany has made of the problem of obtaining and maintaining, at distant stations, practically absolute synchronism, are indeed, bewildering, and justly entitle this gentleman to a place among the world's great inventors.

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A paper read at the Philadelphia Meeting of the American Institute of Electrical Engineers, October, 1884.

THE SCIENTIFIC CITY STREET.

BY ROWLAND R. HAZARD, PREST. GRAMME CO., NEW YORK CITY.

Electricity, in its modern application, is both solving and creating problems. For example, it affords the only method by which the public streets may be used for rapid intramural travel without diminishing the value of property and imposing serious public burdens, while it intolerably disfigures the same streets, with its unsightly and dangerous aerial conductors and supports, which constitute an æsthetic and material nuisance of great magnitude.

Broadway, New York, is the most notable American example of the injury it inflicts and the benefits it offers. For many years engineers have been employed in devising methods for converting its roadway into a rapid transit subterranean thoroughfare; a multitude of plans have been devised, but all have failed to attract financial support or allay local apprehension and opposition, for the reason that no effectual method of removing the products of combustion by mechanical means could be devised, those adopted elsewhere not being successful, or not adapted to the limited space available. No openings in the roadway would be permitted, and many ineffectual attempts have been made to secure ventilation through what was known as the "area" between the sidewalk and the building; meanwhile the area has disappeared by the widening of the walk and the vault itself has become of great value, so that time has increased and not removed the difficulty. Further, as the products of combustion, smoke, ash, cinder, sulphurous acid gas, are heavier than the atmosphere, and the air of the subway damper and cooler than external air, even the most elaborate and expensive systems of ventilation would have proved inadequate to their complete removal. Electricity, however, dispenses with combustion within the subway, and, therefore, a structure which is constructed with reference to dryness, and the continuous passage of a current of external air, wherein the trains are worked by electricity, is freed at once from all the objections to a subway, is the safest, the most comfortable, convenient way, and provides for the fastest possible city travel.

Meanwhile, a general committee on electrical underground communication was formed, representing twenty-one corporations, and a sub-committee was appointed, under the chairmanship of Dr. Henry Morton, of the Stevens Institute of Technology, to study and report upon the practicability of disposing of all electric wires and conductors underground, the accumulation of poles and wires having become a public nuisance. This committee received its instructions May 7, 1883, and reported March 15th, 1884. The report was long, learned, and elaborate, involving in its preparation an immense amount of labor in examining devices and collecting testimony from all sources. The summary reads as follows:

"No system submitted to or investigated by the committee seems to fulfill all the requirements so satisfactorily as a properly constructed tunnel of sufficient size to admit the passage of workmen and access to the wires within it. Connecting with this tunnel, conduits of sufficient capacity for lateral wires could be constructed as described.* The multiplicity of subterranean structures in this city might tend to operate disadvantageously, if not to prohibit the construction of such a tunnel, unless the same were arranged to accommodate the gas, steam, and other systems, as well as the electric wires. The deteriorating influences of steam and gas would, however, be apt, by destroying or impairing any system of insulation, to render the success and reliability of any system of conduits in the lower portion of the city questionable."

The first capital requirement of a great thoroughfare is—the accommodation of traffic, sub-divided into several classes. An ideal street should provide a smooth foot-way for the pedestrian, an even and noiseless carriage-way for vehicles, *and both of these ought to be unobstructed by any permanent or immovable thing whatever*. The present surface impediments will be doomed whenever the citizen obtains access to one example of unobstructed street surface. It must also provide for the travel of the hundreds of millions who wish to avail themselves of a more rapid or a cheaper method, and it must do this without appropriating the surface. The "elevated" road is therefore a temporary and clumsy device for accomplishing this end. It provides the facility, safety, rapidity and cheapness required, at an unspeakable sacrifice of space, quiet, comfort, convenience, health and comeliness. The tramway is the least objectionable form so far devised to meet a part of this demand, and is capable of very great improvement in respect of speed, steadiness, comfort, convenience and economy when the motor supersedes the horse, and a good pavement permits the use of a slightly grooved rail. There remains the vast mass of rapid, long-distance travel, not now provided for at all, and the rapid short-distance travel which the tramway cannot develop sufficient speed to accommodate on Broadway, or upon any narrow and crowded thoroughfare.

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* See p. 17 of that Report.

There are, then, two distinct demands which the requirements of modern life make upon the sub-surface street, which it is the object of the "scientific street" to supply. Broadway is taken as the standard, and reference is made to the plate for illustration. The total width of the street (80 feet) is marked "Public Property." The private fee is shown in black, marked house-line, and is beyond this line. The side-walk is called "City Permit," for the reason that while the title is in the public, it is—underground—almost uniformly in the exclusive use of the abutting proprietor in fee, under license or "permit" from the city. The parts marked "area" and "vault," cover 18 feet from house line to curb line (colored yellow). Neither the one nor the other is disturbed by the lines of railway tunnel, or the galleries for pipes and wires.

The roadway between the curbs is 44 feet in width, and this furnishes all the accommodation required for all purposes. It is divided into two sections, the one, centrally placed, affords accommodation for two "way" and two "express" tunnels, within 35 feet, and is called the "permissive section" (colored red). The sections on either side are 4 feet 6 inches (colored blue) and called the "compulsory sections," because the existing impedimenta of the street must be disposed of at that point of access to the abutting houses. By this disposition of the street all requirements are fulfilled. A smooth, noiseless and unobstructed surface is provided for pedestrian and vehicular traffic, express and way trains for rapid transit, permanent housing for sewer, water, gas, steam, pneumatic, electric conductors and pipes, with access throughout for inspection, *and in all cases in immediate contact with the premises where the connections are to be made.* In neither express or way stations is private property taken, nor at any point does the structure abut private premises, even during construction. The section selected for illustration is north of Dey Street, where the existing obstructions are greatest, including the pneumatic tubes of the Western-Union Company, the heavily "packed" pipes of the Steam Heating Company; and where provision for 4000 electric wires is required.

The method of construction is as follows: street excavation is effected in sections, and is governed by the extent and character of the traffic. A uniform platform of concrete, about two feet in thickness, floored by half-inch of Trinidad asphalt, is first laid, extending across the street at the maximum base depth of about 17 feet, forming a foundation for the whole structure. Upon this is erected the external vault wall (A A), securing to the abutting proprietor the permanent use of the whole vault and area undisturbed throughout the standard section. This vault wall is fitted while under construction with suitable connections for gas, steam, electricity, sewer and water at every house. This wall is also the external wall of the galleries, arranged adjacent to either curb (B B). The galleries are sub-divided longitudinally and continuously, by beams riveted to their internal and inserted in their external walls. Access throughout is provided at the termini and stations, and they are calculated for access to, housing and inspection of the tubes, pipes and wires. The electrical conductors are arranged anti-inductively, upon shelves riveted to the roof and gallery beams, as shown at C. There being no permanent floor above the foundation, the pipes in either gallery are accessible from above or below. Street opening for repair, replacement, or connection is thus wholly obviated. The internal frame supporting the galleries is formed by iron columns, placed four feet apart, and coincident with those forming the outer wall of the way railway tunnels. These columns are composed of two angle-irons riveted, and rest upon a continuous granite foundation. The space remaining between the pipe galleries, which in Broadway is thirty-five feet, is disposed in four railway tunnels, for the accommodation of an up way (D) and express (E), and a down (F) way and express (G) train. These tunnels are formed by five rows of columns each composed of four angle-irons, arranged longitudinally four feet apart, resting on a continuous granite base (H), the spaces between the columns at the foundation and the roof being filled by a panel composed of a tough, non-resonant material, secured by clamping-bars to elongated flanges of the columns, free but reinforced top and bottom. This panel fulfills a double function, it completes the tunnel for purposes of ventilation, and it prevents resonance, which might be caused by the rapid passage of a train through a tunnel with metallic walls. The roof is supported, and the whole structure tied by beams placed four feet from centres (J), which extend across the entire span, bolted at every eight feet to the tunnel columns, the ends being inserted in the vault wall. Upon these beams the steel ten-inch-span buckle-plate roof is laid and bolted; over this is a two-inch skin of Trinidad asphalt, as a protector from chemical contact and dampness, and as a slight cushion. Above this is placed six inches of concrete, which completes the permanent street. This structure as a whole contemplates the minimum of excavation, the maximum of capacity, the greatest number and most equal distribution of points of support, and consequent maximum of firmness and steadiness in use.

The railway tunnels form open cylinders from station to station, and the trains being of approximate cross-section constitute loose pistons always moving in the same direction; the obvious effect is the establishment of a ventilating current, dependent for its force upon the approximation of cross-sections and the speed of the trains; as the products of artifical combustion are excluded from the tunnels the requirements of ventilation are reduced to a minimum, and perfectly performed. The traffic-rails and the electrical conductor-conduit are bolted to the same steel tie (L), which arrangement secures perfect alignment, the tie being permanently set in the concrete foundation. The modern wood pavement now used in London and Paris, should be substituted for the noisy granite. This is constructed upon the correct theory that the surface is not an enduring part of the street, but that it bears the same relation to it that a woolen carpet does to an ordinary floor, that is, that it provides a comparatively temporary, soft and agreeable surface for wear, while it protects the floor itself from destruction. This pavement, like a carpet, is easily and cheaply repaired or renewed, and provides at once a smooth, easily cleaned and noiseless surface for traffic. Stations for way trains are approached from side streets, by entrances placed at the curb lines, the passage being faced with white enamelled brick, while the platform is placed in the space occupied in the standard section by the pipes and wires (they being specially arranged at stations), and a portion of the vaults only, but in no case any part of the area. The express stations are "double decked," and occupy but little space inside the curb line. There are entrances to stations at twenty two streets, between the Battery and the Hudson River terminus, at Vanderbilt avenue.

The steam plant for generating electricity for the railway service provides ten thousand horse-power, and the passenger capacity of the road will be about equal to that of the entire elevated railway system, as now worked. The railway carriages will be of unbreakable material and of standard gauge, so that they may be worked over the lines of any connecting trunk railways, which may provide an electric-conductor between the traffic rails. The devices of many electrical engineers and inventors will be employed in the complex designs for moving, switching, signaling, braking, lighting and regulating the numerous heavy trains required by these fast services.

Modifications of this specific design will be required under the variety of conditions imposed by varying widths and grades, but I venture to hope that its realization on Broadway will lead to the adoption of the sub-way for rapid travel in cities to the exclusion of any surface structures whatever. Meanwhile, an electric equipment for both elevated and surface roads, which is entirely within the present resources of the art, will diminish their offensiveness as far as is possible in the nature of things.

Note.—In the standard sections the disposition of pipes and wires in the galleries is: water-main, M: water distribution, N; sewer, O; gas-main, P; gas distribution, Q; street gas, R; steam pipes, S; pneumatic tubes, T.

Read at the Philadelphia meeting of the American Institute of Electrical Engineers, October, 1884.

AN EXPERIMENTAL METHOD OF STUDYING THE DYNAMO MACHINE.

BY PROF. C. F. BRACKETT, PRINCETON, N. J.

I propose to give a short account of a method of experimentally investigating the dynamo machine, which has been devised and put in practice in the Physical Laboratory of the College of New Jersey. Its principal feature consists in the use of an exploring coil, by means of which it is easy to determine the relative value of any point of the magnetic field in which the armature revolves. (1.) When the field magnets are excited by their normal current, generated by another machine, the armature of the machine under investigation being removed. (2.) When the field is modified by the presence of the iron core of the armature revolving without the usually accompanying coils. (3.) When the field is modified by the action of the coils of the armature revolving without their iron core, but carrying the current which usually traverses them. (4.) When the normally constructed armature is in operation in the production of the current in the ordinary way.

In order to estimate the energy consumed in any given case, the machine has its field-magnets balanced on knife edges, as I have elsewhere pointed out. The couple required to hold the magnets in opposition to the couple tending to make them revolve and the measured velocity of revolution enables us to determine the power expended in any given case.

The special arrangements are as follows:

(1.) The armature is removed from the arbor and in its place is secured a wooden hub, to which is attached the exploring coil, the latter having the same form as one of the coils of the armature though it may consist of one or of many turns of fine insulated wire, the number being determined by the conditions involved in the case under consideration. One end of the wire of the exploring coil enters a hole in its side and passes along the axis of the arbor, which is bored out for that purpose, and comes out centrally at its end, where it is soldered to a short cylindrical wire of steel, which is fixed by an insulating plug to the extremity of the arbor and concentrically with it. This steel wire passes through the side of an iron cup below the surface of mercury which it contains. The cup is supported by an insulating stand. The other end of the wire of the coil is soldered to the single narrow bar of a commutator cylinder which is fixed to the arbor and so arranged that it can be set coaxially, but so that a radius passing through the bar shall make any required angle with a radius passing through the exploring coil already described.

A divided circle fixed to the field magnets enables this to be done conveniently. A spring or "brush," insulated from the metal of the machine, is so adjusted that it shall touch the bar at the instant it is passing under it. If a wire join this spring to the mercury in the iron cup there will be a closed metallic circuit at the moment when the brush is in contact with the commutator bar; and since the coil is moving through the magnetic field, due to the field magnet, there will be at that instant an electromotive force, and so a current set up in the coil. This is evidently repeated at every revolution, and, if these be rapid enough, the result will approach in character a continuous current.

If we introduce into the circuit a condenser it will be fully charged at the potential due to the intensity of the field at the point passed by the exploring coil at the instant when the commutator coil is in contact with the brush. The condenser may be discharged through a ballistic galvanometer and the deflection noted. If, now, the commutator be so set as to be in contact with the brush when the exploring coil is passing another point in the field, whose angular position with respect to the first is known, and the observation made by means of the condenser and galvanometer, we shall have the relative value of the field at this point. We can proceed in like manner to determine the potential at as many points in the field as we desire. We thus have the necessary data for plotting a curve that shall show the distribution of the free magnetism of the field in which the armature of the machine turns when it is present. Instead of the condenser and the ballistic galvanometer, the quadrant electrometer may be employed more conveniently. It is in this case necessary to see that the electrometer is not affected by charges which have their origin in the friction of the belt which drives the machine. Proper care being taken to avoid such accidental disturbances, we may evidently plot our curve from the direct readings of the electrometer.

(2.) An exploring-coil is now placed on an iron ring, in all respects similar to that employed in the construction of the normal armature. And the ends are joined in exactly the same way as before. The coil is driven with uniform speed as before and the several observations are taken in the same way, and the result is plotted. The resulting curve shows how the magnetic field due to the field magnets is modified by the presence of the revolving iron ring.

(3.) An armature, in all respects similar to the normal armature of the machine, except that it is wound on a wooden core, is now placed on the arbor. An exploring-coil is wound upon it properly as before. The commutator brushes of the machine are put in place and adjusted, so that the current from the feeding machine shall traverse not only the magnets but also the armature. Now, on causing the machine to revolve with uniform velocity, as before, we can find the necessary data for plotting the curve representing the magnetic field, as modified by the presence of the revolving coils together with the currents which traverse them.

(4.) The proper armature of the machine is now put in place and an exploring coil is wound upon it as in the last case.

The proper connections are made and the readings of the electrometer, as affected by the coil in the different positions which it is successively made to assume are taken. The curve plotted from them shows the character of the field as modified by the action of the armature. It is obvious that we may now use the method of exploration here pointed out to determine what are the modifications due to different speeds of revolution. Also we may employ it to determine the proper form of the "cheek pieces" of the field magnets, the proper amount of iron to give the best results, and a great variety of other matters that will readily occur to one. The exact method of joining the ends of the exploring-coil to the electrometer which is here pointed out need not be followed in every case, as alternate methods will suggest themselves.

DISCUSSION.

MR. GEORGE C. MAYNARD in the chair.

The SECRETARY:—I would like to ask Professor Brackett this question, whether there is any source of error in the use of the coil upon the wooden ring due to the counter-inductive influence of the field magnet upon the inner portion of the coil, that is, that portion of the coil that is nearest the axis?

MR. BRACKETT:—On that head I will say something that will interest I think the gentlemen present. It is found, when we put in the Gramme ring, wound on a wooden core instead of an iron core, and drive it within field magnets, excited to the very same intensity as in an ordinary case, that whereas I should get driving it three thousand turns per minute, instead twenty Amperes, the normal current, I get about six Amperes, and in an opposite direction. Do you comprehend the answer to your question? The current is reversed when I use a wooden core. That is precisely the condition involved in the question of Mr. Keith. For here having no iron present, I have simply the return wire at this point.

Now, speaking directly to the point, I have to say, it is in that case the differential effect between one of these and the other, and if the same set of circumstances exists that differential effect may be presumed to be pro rata to the difference of area—take it all the way round. So that whatever may be said it does not depend upon the correctness, or interfere with the correctness of the distribution of the lines of force, not the slightest. But it does completely mislead the student who supposes that he is going to have a current in the same direction; he will have it in the opposite.

Mr. Keith:—Why?

Prof. Brackett:—I rather you would not ask me that question.

Mr. Sperry:—I would like to ask you another question as to the ratio of Amperes.

Prof. Brackett:—About twenty in one direction; six in the other. That is twenty-six degrees difference. One is in the opposite direction, twenty Amperes, proving the current is in the other direction.

Mr. Kelly:—The negative current does not absorb the power.

Prof. Brackett:—It is a very curious result, and a striking one.

Mr. Keith:—Mr. Chairman and gentlemen, this to me is a very curious result. The paper is a very interesting one to me, and I am in hopes of being able to carry out this line of experiments on some machines that I have as yet in my head. And I would also remark that his mode of exploring the external magnetic field is a very good one. This afternoon there will be presented a method of exploring the magnetic field by Mr. Mailloux, using an induction coil and a telephone, and drawing his deduction from the tone or the note which is made in the telephone by the various actions which take place in the external field.

Speaking in my official capacity as Secretary, I hope we will have a good attendance when that paper is read.

A paper read before the American Institute of Electrical Engineers, Philadelphia, October, 1884.

EARTH WIRES; OR, THE EARTH AS AN ELECTRIC CIRCUIT COMPLETER.

BY THOS. D. LOCKWOOD, ELECTRICIAN, AM. BELL TEL. CO.

To earth-dwellers, and especially to that portion of the race who are practically interested in the form of molecular motion, which we call Electricity, there is no element or adjunct of electrical science more important in many respects than the terrestrial ball itself, when we consider it in its relationship to the electrical circuit—whether that circuit be inductive or conductive, we are impelled to the opinion that its consequence cannot be too highly estimated.

When used in the arts of electrical communication, it enables us to reduce one-half of the number of line wires, which would otherwise have to be used; and when we consider the immense number of wires that even now fill our streets and line our highways, we cannot fail to reflect upon what might have been, had we been compelled to provide a separate return wire for each telegraphic and telephonic circuit from 1837 until 1884. For not only does the earth assume the functions of a return wire for a multitudinous number of circuits, but when the line wires exceed a few miles in length, the earth return actually completes the circuit in a way which admits of a much smaller expenditure of electrical energy than would be requisite in a line between two points an equal distance apart, connected by a continuous wire circuit; since the resistance of such an earth completed line should not generally exceed more than half of that of a metallic circuit connecting the same two points.

The first instance on record, where the earth or a portion thereof, in the form of water, was used deliberately, as an electrical conductor, to complete an electrical circuit, dates back to July, 1746, when Winkler, of Leipsic, both charged and discharged a battery of three Leyden jars through an insulated wire, thirty-seven and a half yards long, the wire being laid along the bank of the river Pleisse, the waters of which constituted the return part of the circuit. Winkler ascertained by this experiment that the effects of the discharge were not perceptibly different from those observed when a metal discharging rod was used.

About the same time, Le Monnier, of Paris, made similar experiments, and discharged Leyden jars through the water of a tank in the garden of the Tuileries.

We find from Priestley's "History of Electricity," that in England, shortly after the above experiments, Dr. William Watson carried out a number of others in the same line, under the auspices of the Royal Society Committee. On the 14th and 18th of July, 1747, the first experiments were made, a wire being carried over the river Thames on Westminster bridge, the water of the river serving as a return path for the current. On the 24th of the same month, a similar trial was made in a circuit of two miles, at the New River, near London. Two trials were here made; in one of these the electricity successfully traversed a distance of 800 feet overland, and 2,000 feet by water; and in the other, the circuit comprised 2,800 feet of land and 8,000 feet of water. In August of the same year it was discovered by Watson that dry ground conducted the subtle force quite as well as water. Again, on August 14th, 1747, at Shooters' Hill, a circuit was experimented with, consisting of two miles of wire and two miles of dry ground. In all of the above trials the electricity was effectually conducted by the earth acting practically as a return circuit.

Finally, in 1748 and 1749, these results were verified by Franklin and De Luc. We may note here, by the way, that nearly all of the early proposers or devisers of early electric telegraphs, from Le Sage down to Dyer, had intended to employ the earth as a return.

It is also, however, to be remarked that all of the above instances were experiments with high tension electricity; and that thus, if there had been no examples in which voltaic circuits had been completed through the earth, our fathers might have been excused in waiting for Steinheil. But such examples are not wanting, and the conductibility of the earth with respect to chemically generated electricity was also known for a long time anterior to Steinheil.

In February, in 1803, Aldini sent a current from a battery of eighty silver and zinc plates from one side of Calais harbor to the other through a wire supported on masts, the return being through 200 feet of water. He also repeated the same experiment at Paris and Alford, using the rivers Seine and Marne.

Basse, of Hameln, in the same year made a series of experiments by which he fully established the fact that the earth could he used as a part of a voltaic circuit.

Erman, of Potsdam, somewhat later, verified these results in the waters of the Hamel; and eight years later (1811) Soemmering and Schilling performed almost identical experiments with a view to establish the feasibility of using the earth as part of any electric circuit.

These are the historical circumstances which form a basis for the present system of earth completed circuits; and we may clearly see, that as early as the beginning of this century, the fact that the substance of the earth in the form either of water or dry ground could be used as part of an electric circuit was well established.

In view of these circumstances, it seems very strange that the earth circuit was not used, or even with one exception proposed, for telegraphs, until used by Steinheil in 1838. It is rather difficult to see why a well settled knowledge of the above circumstances which, if acted upon, would at once have halved the number of wires required, was not utilized until so late, even by Schilling and Soemmering, who were two of the earliest telegraphic inventors, and who both, although instrumental in demonstrating the truth by experiment, failed to apply it to their telegraph system.

As we shall presently see by Steinheil's own writings, his idea, to use the earth as a return, was in a measure forced upon him, being an observation made of the result of an experiment tried for quite another purpose.

*Singularly enough, his discovery was foreshadowed in a letter signed "Corpusculum," dated December 8th, 1837, and published in the Mechanic's Magazine. This letter speaks of the numerous designs for telegraphs, which were then being brought forward, and says that he, too, formed one, and prepared a specification for it, five years ago, including a plan of making one wire only serve for the return circuit for all the rest * * * ; "*but even that,*" he goes on to say, "*might I think be dispensed with, where a good discharging train, as gas or water pipes, at each end of the telegraph could be obtained.*"

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* Vide Fahie's History of the Early Telegraphs, p. 345. London, 1884.

The *application* of the earth itself, as a return, and a *common* return circuit for telegraph wires, came about in this way:—

Prof. C. A. Steinheil, of Munich, had in the year 1836—1837 constructed a telegraph line, and devised a most ingenious system of operation for the same. In consequence of a suggestion made by Counsellor Gauss (who in conjunction with Prof. Weber was also a telegraphic inventor of no mean order), that the two rails of a railway might be used as conductors for the electric telegraph, Prof. Steinheil, in 1838, tried the experiment on the railroad between Nurnberg and Fuerth. He was, however, unable to insulate the rails properly, and he found that the electricity passed from one rail to the other through the earth. He then used one rail as the return wire, the direct line being an insulated wire, and found it to work perfectly, for the rail itself acted not only as a return, but also as an earth plate.

Subsequently, he discarded the rail, and substituted earth plates at both ends.

It must not for a moment be supposed that the intent of this paper is to belittle the deservedly great fame of Steinheil. If the experiments, which had gone before, affect him in the least, it is but to enhance his perception; since he first had the wit to apply to a practical use what so many had experimented upon and amused themselves with.

I regard his eminently practical application, as being one of the most important ever made, and it certainly gave the art of electric telegraphy an impetus which nothing else could have done; and has contributed immensely to the development and extension of the telegraphs of the world.

This extremely useful suggestion had two great immediate advantages; it halved at once the number of required wires, and since the earth compared with a long line has no appreciable resistance, it doubled the strength of the telegraphic currents; or in other words enabled an halved electromotive force to produce an equal current strength.

The remarks of Professor Steinheil upon this subject are still so pertinent that I make no apology for quoting them here. He writes:

" Quite recently I have made the discovery that the ground may be employed as one-half of the conducting chain forming the circuit with the line wire. As in the case of frictional electricity, water or the ground may with the voltaic current form a portion of the connecting wire. Owing to the low conducting power of these bodies compared with metals, it is necessary that at the two places where the metal conductor is in connection with the semi-conductor, the former should present very large surfaces of contact. Taking water, for example, which conducts two million times worse than copper, a surface of water proportional to this must be brought in contact with the copper, to enable the voltaic current to meet with equal resistance in equal distances of water and metal; thus, if the section of a copper wire is 0.5 of a square line, it will require a copper plate of sixty-one square feet surface in order to conduct the voltaic current through the ground as the wire in question would conduct it. But as the thickness of metal is quite immaterial in this case, it will always be within our reach to get the requisite surfaces of contact at no great expense."

When Steinheil made his discovery he, as well as other physicists, thought that the earth actually conveyed the electricity from one plate to the other just as a wire does.

This idea was strengthened by experiments subsequently made by Matteucci and Baumgartner, and it is no doubt approximately correct in the case of very short lines.

Later observations do not seem to confirm the correctness of this hypothesis, and it is thought now by the leading minds which have considered the subject, that the earth performs the part in relation to a voltaic circuit with which it is connected, of an extremely large conductor of almost infinitely large mass, capable of absorbing the electricity as fast as it is developed, and thus maintaining the ends of the conducting line at a potential of zero, and permitting the battery (one pole of which, that connected with the line, is a certain degree either of a higher or lower potential than the earth) to work and maintain a flow of electricity until its materials are exhausted.

The evidence is greatly in favor of the latter hypothesis; and I have no hesitation in adopting it in preference to the view which considers the earth as a real return conductor, bringing the current of every source back again to its starting point.

As Electrical Engineers, however, it concerns us more to know that we can in many cases advantageously substitute an earth connection for a return wire, than to speculate upon the why and wherefore of the fact, except in so far as such speculations aid us in determining the best and most efficient methods and conditions of such substitution. Although the resistance of the earth when used as a circuit completer is very rarely of much importance, it still has a certain value, which rapidly decreases as the length of the wire part of the circuit increases, and it is estimated that it becomes too small to be taken into account when the line is over 75 miles long. If therefore we have a long line we need scarcely regard the absolute resistance of the earth, which is in relation to the line wire infinitely small, and we may say that the resistance of the entire circuit is only half of what it would be were the circuit entirely metallic.

But if the line is very short, the resistance of its conductor is correspondingly small, and the resistance of the earth becomes a more important factor in the case, and we cannot therefore regard it as nil, without introducing an error of greater or less degree.

The late Count Du Moncel made observations which tend to show that the resistance of the earth under very favorable conditions is equal to that of a No. 8 line wire of about seven miles in length. When, therefore, the resistance of the line wire is not over ninety or one hundred ohms, it does not seem advantageous if we desire the best electrical results, to use an earth return. By reason, however, of the increased economy in material involved, we would generally use earth terminals for an ordinary circuit as short as half a mile, unless the two ends of the wire, after the stations were all passed, could be brought conveniently near to one another; especially if satisfactory earth connections could be obtained. The last consideration brings us to another point: In addition to the absolute resistance of the earth itself, there is also more or less resistance between the plates and the earth. Here we may very properly recur to Steinheil's view and regard the earth for a time as a return wire, and the earth plate as a joint or connection between the main and return circuit; and in consequence, as a joint between a good conductor and a bad one. This view shows us the necessity of the utmost care in making earth connections, and may be exemplified by assuming that we have to connect a copper wire to an iron wire of the same conductivity, but of course differing widely in size; the iron wire we may assume is No. 8, has a diameter of 165 mils, and a resistance per mile of about 13 ohms per mile. A copper wire of almost an equal degree of conductivity is No. 16, which has a diameter of 65 mils; the diameter of the iron wire is thus about two and a half times that of the copper wire, and its sectional area is about six and a half times greater. If now we should bring the ends of the two wires squarely against one another, it is clear that more than five-sixths of the area surface of the iron wire would not be touched at all by the copper, and would not therefore aid in making a good point. The conductive lines of the joint are only equal to a smaller section of the iron wire.

Such a joint is of course very defective, but if the copper were enlarged so as to cover the entire end of the iron wire, the whole section of iron is utilized, and the joint is perfect. Applying this idea to the subject in hand, as described by Steinheil; inasmuch as the relative difference between ordinary iron line wire and the earth is at least one million, we find that the iron should at the junction be expanded to at least one million times its original surface, or the joint will be defective, for in practice the terminal connection of a line with the earth is virtually that of a joint. But if the two ground plates are of sufficient size for each of them to bring a surface a million times greater than that of their iron wire section into contact with the earth, the joints as compared with iron are perfect.

Thus we see that if we do not bring a knowledge of applied electricity and its laws to bear, even in the little matter of terminal grounds, we may introduce considerable unwarrantable and unnecessary resistance into an otherwise good line, and we shall then have a line which can never be worked economically.

The ground terminal of a telegraph may well, on account of its importance to the entire circuit, be regarded as the ground in another sense—the ground work or foundation upon which the entire modern telegraph system rests.

The ground or earth wire, of course, is always used to complete a circuit, but under many and varying conditions.

The earth wire may be used as a terminal for a single line, for a few lines, or for many lines.

It may be employed for a regular testing earth at a station, or for a temporary testing earth between stations in times of circuit trouble. We find, moreover, that the earth wire is also essential as an attachment to the lightning arrester or guard with which we protect our delicate instruments from the attacks of electricity in its most impressive form.

Sometimes also it is found necessary to protect the telegraph poles themselves by lightning rods, so that even the lightning rod itself, long regarded as the exclusive property of the charlatan and the electric quack, in its character of a ground wire, demands the consideration of the electric engineer.

TERMINAL EARTH WIRES.

In our large cities, good earth can always be obtained upon water or gas pipes, so that the idea of the Mechanic's Magazine writer, already referred to, is realized. Moreover, in many city buildings, at the present time, earth for many purposes can be obtained on almost any metallic surface to be found in the building, notably the pipes of steam heaters or radiators. It is always best to use a water pipe, if obtainable, because piping is often defective in conductivity at the joint, and in the water pipe the liquid itself aids in conducting the electricity. If gas pipes only are to be obtained, an attempt should be made to connect the wire thereto outside of the meter (this especially, if there be but one meter in the building); as otherwise the removal of the meter severs the connection with the earth entirely. If several series of water or gas pipes or both are at hand, I would make assurance doubly sure by connecting the earth wire with all of them.

In any case, the pipe should first at the point of attachment be filed quite clean and bright. A good earth may then be made by first winding a long stretch of copper wire of small size, say No. 16, smoothly and very tightly round the brightened pipe, until about six or eight inches of the pipe is longitudinally covered. This may be tightened up by passing the last few convolutions through one another, and it should be then well soldered to the pipe, leaving a loose end of about eighteen inches. This end should be spliced by a long and neat joint to a No. 6 or 4 main copper wire, which should previously be wound smoothly round the pipe, some eight or ten turns. The spliced ends may now be laid over the convolutions lengthways, and the whole again soldered. The large copper wire leads through the instruments to the line. This forms a good and reliable earth connection. The trouble with terminal wires is that they are frequently too small.

Earth wire clamps to be screwed to a pipe, and which are furnished with a binding screw for the wire are very good, provided they are made with a sufficient amount of longitudinal surface, which may be brought in contact with the brightened pipe, and fitted with a tight screw which will not work loose.

If a large and long clamp cannot be obtained, a number of small ones may be used, and all should have a movable plate of copper or brass between the ends of the clamping screws and the pipe, so that not the screw ends only, but a good surface under them can make the contact with the pipe.

In many places, especially in the country and in newly settled districts, there are still no pipes, and an earth plate has then to be buried.

Bars or wire ropes are by no means as effectual as earth plates.

These plates ought always to be made of copper, or of zinced or tinned iron.

These materials are recommended not on account of any degree of conductivity which they possess, but because their metallic surface is much longer maintained.

Ordinary iron, rusts through much too quick to be any use.

The plates should never be smaller than three feet by four, and they ought to be about one-eighth of an inch thick.

To make a first-class earth, two large insulated copper wires, say No. 6, should be used to connect with the plates, and holes being made through the plates, the ends of the wires may be threaded through; about four holes for each wire will do. The wires should then be soldered to the plate at each hole.

In setting the plate, the hole should be dug until damp earth is reached, and the plate must be set vertically, so that its upper edge does not come above the level of dampness. All strain should be taken from the wires, and above the surface of the ground they may be soldered together, and then to a single iron wire leading to the office and line.

I hold that all points of an earth wire from the instruments to the earth should be well insulated, so that no electrolytic action can arise, due to leakage, at midway points. When the earth wire is to serve as the terminal of many wires, it should be as large as can be conveniently handled. Telephone exchanges of many wires can readily be operated without any main terminal earth wire, as each wire finds earth by way of all the others. Some offices are so worked. We prefer, however, an earth terminal of the highest character, as it is quite conceivable that half of the lines may be in use at one time, in which case the joint resistance of the remainder may be rather high; certainly much higher than the normal joint resistance.

Testing Earth Wires.

These, when at offices, ought to be as perfect as terminal earth wires, especially at terminal or testing stations.

At way, or intermediate stations, this is not so important, as there the earth wire should only be used in the event of circuit trouble. At the terminal station the earth wire may be constructed in the same way as the method described for the terminal. Such a long splice, if a pipe is used, is however, not absolutely so essential. To insure accuracy of testing operations, the resistance of the testing earth wire should be frequently measured.

At a way station, earth can sometimes be temporarily obtained from the rails of the railway, but the earth plate is the only plan I should recommend for a permanency.

Lightning Arrester Earths.

These should be made of the largest copper wire that can be procured and handled, as they sometimes have to convey very heavy discharges. They are to be connected according to the descriptions already given, except that when located in a cable box, they may be attached to the cable armor instead of to a plate. If possible they should invariably terminate at a different plate from that of the terminal wire.

Pole Lightning Rods.

These are for the protection of poles. They may be led from a point about two feet above the pole, down the side thereof, being secured by staple, and terminate in a plate buried in damp earth at the foot of the pole. Unless, however, good earth is made the pole is safer without any wire. When used, they should have branches running out on the cross arms to within half an inch from each insulator.

Any earth wire can readily be measured for resistance in like manner with any other conductor.

No earth wire and plate should measure more than ten ohms.

In conclusion: If earth wires are employed, they should always be of the same metal, as otherwise they will generate currents themselves by virtue of the difference in potential between the two plates, one of them being electro-positive to the other.

I have long been impressed with the pre-eminent importance of this subject, and while I can scarcely hope that I have done it the justice it deserves, I have tried to make it both practical and interesting, and it may perhaps incite others to give us something better worthy of your attention.

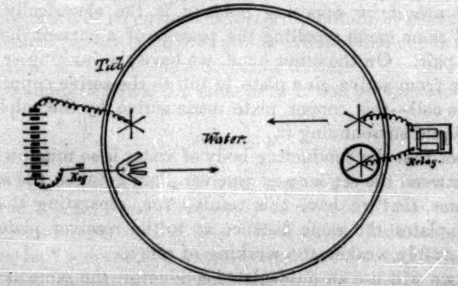
A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884.

TELEGRAPHING WITHOUT WIRES—AN EXPERIMENT.

BY S. J. M. BEAR.

Materials.—A tub of water, ten cells voltaic battery, two copper earth-plates, one zinc earth-plate, and one porous cell, containing a copper plate, immersed in a solution of sulphate of copper, making the fourth ground connection; a relay, or other receiving instrument, of about two hundred ohms resistance, and a transmitting key.

Arrangement of Parts.—All of the battery outside of the tub, with key in circuit, is connected with the water at one part of the tub, and the relay is connected to the water directly opposite. The zinc plate of battery is connected with copper plate in water, and copper plate of battery is in connection with zinc plate in water. These battery terminals in the tub may be quite close together, but must not be in metallic contact with each other. The relay has one terminal in connection with a copper plate in the water, and the other terminal connected with the copper in porous cell in the water; and these two last connections may also be close to each other.



Now, by opening and closing the battery circuit outside the tub, signals may be heard from the relay in response.

Thus, regardless of the relative distance between the ground-plates, electric impulses are transmitted through the water without any insulation between the outgoing and incoming current.

In this way, two continuous currents may pass each other closely in opposite directions at the same time, in the same conductor; or, in other words, the same current passes itself closely in the same conductor; or, if you please, the positive and negative currents are uninsulated in the same narrow circuit.

Then, what prevents the battery current from crossing over between the earth-plates at the sending station? A part of it does so short-circuit, whether an uninsulated wire is used for half the circuit, which we shall see further on, or as above without any wire.

The resistance of water between the sending earth-plates is probably but a few ohms, and yet we have enough of the current out and returned through many times greater resistance of water, to operate the relay, itself of two hundred ohms resistance.

Then, what is the resistance between the sending earth-plates, that causes so much of the current to take the apparently longer route? May it not be the resistance of opposing polarity? For here we have the circuit at the sending-end from the zinc terminal of the battery to and through another active zinc in the tub before it reaches the copper terminal of the battery. It is assumed that the copper earth-plates in the water in the tub are practically inactive, that is, not generating any electricity, but only performing the simple functions of conductors, or circuit connections. What is meant by opposing polarity, is the electrically active plates of same name repelling the passage of a current direct between a pair. On the other hand, we have the inviting or down-hill route from active zinc plate in tub to the active copper plate in porous cell—this copper plate made active by the sulphate of copper liquid surrounding it.

It is not that the conducting body of water is so much wider or larger between the sender and receiver than between the sending earth-plates, that we have this result; for, separating the sending earth-plates the same distance as to the receiver plates does not perceptibly weaken the working of relay.

Now, we will use an uninsulated conductor, the same as a bare copper wire, for half the circuit; or, more properly, as shown, "ground" one-half the circuit, that is usually insulated, by making metallic contact between the inactive coppers, and add any number of such plates, giving all the surface connection possible with the water for establishing a "ground," and yet in this case nearly all the current generated in battery goes the apparently longer route, by the resistance of relay, and having the smaller surface connections.

Neither is the relay operated by the divided single cell in the tub—the active zinc at battery and the active copper at relay, completing its circuit through relay, conductors, battery, key, active zinc, water, and active copper, back to relay—for, by cutting off all the main battery, we find this divided, or tub-cell, fails to operate the relay, even on the same adjustment as the "without wire" plan. I believe this theory is correct, that it is the repulsion of the polarized active ground plates of same name that resists the short-circuiting, as connecting the zincs of two cells together, and the coppers of same cells together by wire, will not produce good voltaic action. Then we may assume that the outgoing and incoming currents in the tub repel or bend each other apart, like the lines of force in a magnetic field; and, continuing the magnetic analogy, we have for the sending earth-plates north pole repelling north pole for the short circuit, while through the relay circuit we have, like the attraction between a north and south pole, the inviting route.

I believe that a certain fraction of current flows to relay, represented by one as a numerator, and the number of cells as a denominator; that is, a fixed part of current cannot overcome the resistance of same polarity, viz.: if a main battery of ten cells is used, one-tenth of its current cannot short-circuit in above arrangement, and if twenty cells, then one-twentieth flows out to receiver; the smaller portion of current being weakened by the resistance through which it flows, the same as if it had an insulated circuit.

DISCUSSION.

Mr. **Bear**:—Now, I will add that with the wire plan, or "ground" plan, I have frequently connected all the coppers for which I had room in the tub. With these (indicating) several coppers, half a dozen or a dozen, we get surface, taking up all the room there (indicating). I have put plenty of common salt in the water, as it is well known to reduce the resistance, that, if possible, I might allow but little of the current to flow across the longer circuit, and, therefore, not leave anything to operate the relay;

but the relay would operate much stronger that way than by the "without wire" plan. What I mean is, that to make the ground connection here as good as possible by saturating the water with salt, so that no more salt would be absorbed in the water, the relay would operate very strongly; I should judge at least half the battery current flowing to the relay. I would further add, that I have never had the opportunity of testing these two different plans, based upon, as I consider, the same principle. I have never had an opportunity to test it with instruments of precision; I have only used common telegraphic instruments, a relay and a sounder; but I tested it through salt water, water of the Atlantic Ocean, in a little bay, with about a half a mile of uninsulated wire, but not having a strong battery force—three or four cells only—I got all the results from it I expected to with such a small battery, but they were very weak. I used a sounder, and with three or four cells to the battery and half a mile of uninsulated wire, I was only able to affect the sounder with the very weakest adjustment; it would not affect the relay at all, I presume, by my not having battery enough, but the sounder certainly was affected at the distant end through the uninsulated wire immersed in the ocean water. I had a common laborer hear the sounder operate, so that it was not my prejudice that supposed that it operated. Those are the severest tests I have put the apparatus to. [Applause.]

The CHAIRMAN:—Gentlemen, you have just heard Mr. Bear's very interesting remarks. A discussion is now in order on the subject.

Mr. JAMES KELLY:—I wish to ask a question. The sounder was certainly affected, you say, and the relay not at all. I would like to ask how the sounder was affected without affecting the relay?

Mr. KEITH:—He had no relay.

Mr. BEAR:—That is a very pertinent question, because telegraph operators, these gentlemen know, generally use a sounder and relay together, but in this case I only used a sounder in a circuit by itself. The sounder was in the main circuit; I did not use the relay at all at the time; I used the sounder.

Mr. PARTZ:—I don't think the explanation is quite satisfactory. The gentleman assumes that the current passes through water, that it takes the trouble of passing through the relay in order to return, while it might have a much easier route and go through the water; I don't think the current will take that trouble. I believe the current goes from one electrode to the other. The current that you get through the relay is simply an induction current. You want a much stronger battery in order to work this than you would by simply pushing the current through the water. That could be done with a very few elements. You have got this section of water into these lines of force, therefore, you have got to push your current with such force that it extends considerably into the water in order to produce an induced current; and that is what you get through your relay; that is my opinion.

Mr. **Bear**:—In reply, I would acknowledge my ignorance, if that current in the relay is produced by induction. The current in the relay is continuous. As I understand induction, when I would close the key of the battery there might be a temporary impulse, an instantaneous impulse of induction through the relay; but in this case the relay remains, as the operators call it, "closed." Therefore I take it it is not an induced current.

Mr. **Partz**:—Yes; but you don't get any manifestations until you work your key.

Mr. **Bear**:—I just stated, and I intended to make it plain, that I did get a manifestation of the current by having, as every telegraph operator understands, the sounder or relay closed, and being properly adjusted. That is evidence that there is a continuous current flowing through the relay.

Mr. **Bailey**:—I would like to ask the gentleman who has given this exhibition how closely those electrodes leading from the battery to the key have been placed together.

Mr. **Bear**:—Yes, sir; I will state, one of our most prominent electricians made this *experimentum crucis* himself. I had not made it before, I believe; he took the copper and the zinc and interlocked them like my fingers (indicating) as closely as possible without touching, then separated them as far as possible. But apparently it made no difference in the operation of the relay when that test was made.

Mr. **Bailey**:—Was that test made while it was in the tub?

Mr. **Bear**:—Yes, sir.

Mr. **Bailey**:—Do you know the distance? Was it the same as it is in this tub?

Mr. **Bear**:—Yes, sir; but I took a different battery. I had ten cells of the common large size—main battery cells, the common blue vitriol gravity battery.

Mr. **Bailey**:—Then, I understand you it was many times the distance between the electrodes leading from the key and the battery; many times that distance, from them to and through the relay and return?

Mr. **Bear**:—The relay circuit was many times greater resistance than the short-circuit of the battery, between the transmitting earth-plates.

Mr. **Bailey**:—That is exactly what I am arriving at. As I understand you, there was no perceptible difference in the action of the relay.

Mr. **Bear**:—There might have been a difference, which would have been shown by a galvanometer.

Mr. **Bailey**:—The relay was working with equal promptness in either case?

Mr. **Bear**:—Yes, sir.

The **Chairman**:—It seems to me that this whole question is one of relative resistance, and had Mr. Bear had the benefit of a galvanometer to increase the amount of his knowledge upon the subject, he perhaps would have arrived at a different conclusion.

Mr. **Maynard**:—I would like to inquire of Mr. Bear whether he has used this system for actual communication by the Morse system over some considerable distance; whether he has not actually telegraphed with the Morse instruments and without insulation for a long distance?

Mr. **Bear**:—No, sir; I have not.

Mr. **Maynard**:—Another question. What do you consider is the practical application of this system?

Mr. **Bear**:—I consider its practical application to be in assisting in the insulation of telegraphic circuits.

Mr. **Maynard**:—Is there any reason why you cannot telegraph across the ocean as well as across the tub?

Mr. **Bear**:—From my theories, and I have studied the subject for several years, I do not know of any reason why not; and I find that the best authorities upon the subject, those that we find published even lately (I believe since the opening of this exhibition), have suggested the placing of one earth-plate in the northern region and the other away south. But that is on the old, or Morse, plan of telegraphing by relative resistances, as I understand it. This, my method, does not depend on the relative resistances, as we understand the term resistance or conductivity.

Mr. **Preece**:—What does it depend upon?

Mr. **Bear**:—I believe it depends upon the counter electromotive force, or polarity; the meaning is the same. As the north pole of the magnet will repel a north pole, although if one north pole is strong enough, it will overcome the weaker north pole; so that if this electromotive force of the main battery is high enough, a great portion of it will overcome the opposing electromotive force of the plate of the same name.

Mr. Keith:—I had understood from Mr. Bear, previous to reading his paper, that he had experimented with this in ponds of considerable size, so that his experiment has been in the water, and on a larger scale than here shown. I think that is what Mr. Maynard wished to get at—whether you had actually carried on an experiment of any considerable size; that is, larger than the tub?

Mr. Bear:—Oh, yes. By the wire plan, but not without wire. I got so much better results with uninsulated wire, and you may readily imagine, by my explanation of this point, that I wanted commercial success. But my idea was that if I used this "without-wire" plan it would only give me one circuit; whereas, we want many circuits. And if I succeeded in operating successfully the uninsulated plan, then I could use any number of circuits close together, so long as they were not in metallic contact.

The Chairman (Mr. W. D. Sargent):—I would ask if Mr. Preece desires to make any remarks upon the subject?

Mr. Preece:—I think the society would, perhaps, like to have the details of a practical experiment bearing on this subject; and I am sorry I was not present during the time the paper was read, for up to the present moment I quite fail to perceive in what this differs from our oldest notions of the mode of communication across water without wires.

It is now, I am almost ashamed to say how many years, but it was in the year 1853 (and 53 from 84 leaves 31), 31 years ago, there was a Mr. Lindsey, a Scotchman, who came to London with the notion, shared in by a great many people since, that he was going to make an enormous fortune, because he had discovered a mode of transmission across water without the aid of wires. He came to the electrical company, to which I was then attached, and made an experiment exactly similar, so far as I see, to that which has been made here. We gave him a tank about the size of this table, about 8 or 10 feet long, and about four feet wide, and in that tank he placed four copper plates, arranged exactly as shown here, but the instrument used was not a relay; it was an ordinary Wheatstone signal needle; and we certainly got effects through it, which showed distinctly that it was possible by such an arrangement as that to transmit electrical signals across water without the aid of wires at all; and the experiment was sufficient to justify its being tried on a larger scale. So he was allowed to experiment, I think, upon the river Tay, I can't quite recollect what river it was, but it was, at any rate, some river in Scotland. Two wires were located some few miles along the banks on either side, and the experiment was repeated, and was again successful. The only effects on the galvanometer were evidently less in actual practice than they were when the experiment was in the insulated tub or tank, such as we gave him. The result of that experiment was sufficient to prove the whole theory of the thing, but it was seen that it was not practical with the then instruments. I took a little interest in the matter at the time, but I had the impression that such an experiment was described, I think, in a very old and valuable book published in this country by Mr. Albert Vail; I think Mr. Morse, or somebody, if not Mr. Morse himself, made a very similar experiment herein. Anyhow that experiment remained in abeyance for a great many years, and it was only when the telephone was brought into existence, with its excessive sensitiveness, that we were induced to repeat the experiment.

It happened that a cable connecting the Isle of Wight, in the South of England, to the mainland broke. The Isle of Wight is a place where the Queen has one of her residences, and we are very careful in maintaining telegraphic communication complete there. The Isle of Wight is shaped something like that. [Illustrating on blackboard.] Here is Southampton, there is a spot of land going out there called Hurst Castle, Southampton Castle coming up there, and there is the town of Portsmouth. [Indicating.] There is the town of Southampton, and there is Hurst Castle. This is the Isle of Wight, and this is Newport, the Queen's residence, and that place is Ryde. [Indicating.] Now wires come from Southampton to that place, and the cable crosses there; they go from Newport into Osborn and Ryde. A few go to Southampton and Portsmouth. Now, here was a very good opportunity to test this very fact; and I had the cable earth-plates placed in the sea, and the wire was carried to the end of the pier, with the cable plates there and there. [Indicating.] So the circuit was completed, with about a mile of sea there, and six miles of sea over there. [Indicating.] The operators were here. They had a telephone here, and a telephone there [indicating], and no sound could be obtained from the voice. With a bugle a faint sound was heard; but when we inserted a buzzer, something like one of the tuning-forks used by Mr. Delany to maintain his vibration, we obtained a buzzing sound, and by the use of the tuning-forks we succeeded in sending currents so rapid as to make sonorous vibrations, and then sounds were distinctly heard there. But when the key was manipulated by the operator at either station, then it was quite possible to transmit signals by making and breaking these buzzing sounds, and thereby to continue the correspondence and to continue the telegraphic communication. Unfortunately for the experiment, this cable that was broken was renewed and repaired that very day the experiment was made, so that we really never carried out this practically. We simply made an experiment as an experiment; but the experiment was so satisfactory that if this cable breaks again, then we shall certainly during the time that it is broken maintain telegraphic communication with the Isle of Wight through the sea circuit arrangement until the cable is repaired.

Now, there is just one little point in this that rather removes it from the category of Mr. Bear's experiment, or Mr. Lindsey's, and that is, that across here you have not absolutely an unbroken piece of water, but you have a cable. The cable was broken probably for the distance of a few fathoms, but at any rate there was a conductor separated by a few inches or a few feet, and it maintained communication across there. On the other hand, here you had an undoubted length of six miles.

Now, I do not see, at present, I may be wrong, in what respect this experiment differs from the one that has been described to you. If we have a river with banks running parallel, and we have an earth-plate there, and a conductor there in each bank, it is quite possible to transmit a current through, when the resistance of that length compares to the ratio of that length, and from all theoretical reasons, it is very easy to give the relation determining that and to show the condition of the strength of current; but I gather from Mr. Bear that he thinks the counter electromotive force is the cause of the matter. I have not the least doubt that it is. But it simply does so because the electromotive force, the reverse electromotive force, becomes exactly the same as his resistance. If you are using a bridge, and you are testing a current, that circuit may have an earth current in it, and if the earth current flows in the same direction as the current you are testing, then your resistance is less than it ought to be; but if that earth current flows in the contrary direction, then your resistance is increased and is greater than it ought to be; so that the influence of counter electromotive force in a current is exactly the same as answers to the true resistance. This experiment has been described to you as in point of fact and theory exactly the same as that which governs the experiment I have given, and is the same as that which is supposed to be within the knowledge of those who read works on electricity, or even in the knowledge of those who make a practical application of the telegraph instruments. That experiment is simply an experiment for illustration of the practical demonstration of the truth of the theory by which we are able to communicate across water without the aid of conducting wires.

Mr. Kelly:—If he has drawn this diagram correctly I don't see how he obtains the electromotive force.

SECOND DISCUSSION.

The Chairman (Mr. George C. Maynard):—Mr. Partz desires to make some remarks on the subject of telegraphing without wires, a subject that was introduced by Mr. Bear yesterday.

Mr. Partz:—As the subject was brought up before you, I thought it might not be out of place to set forth a little scheme of mine of telegraphing without cables through the water. I mentioned the matter yesterday as a sort of curiosity for the time being to Mr. Preece. I will make it as short as possible.

Suppose that this is an irregular section of the globe through its Northern Hemisphere; supposing that here you have Halifax, there Vancouver's Island, or any other point on the Northern Pacific coast, there the mouth of the Amor River in Siberia, and that a point on the west coast of Ireland. Now we have a continuous insulated conductor from Nova Scotia to Vancouver's Island. We have another insulated conductor from the Amor River to Ireland. Now, supposing the current passing through that conductor in that direction, that current must necessarily go through that conductor in that direction, that current must necessarily go around the globe, and consequently you can telegraph without a cable. The current would certainly not go back to Vancouver's Island or to Nova Scotia, that is, take land conductor, as it has a much easier way the other way.

As I said before, it may be a mere curiosity for the present, but we do not know always what these will finally result in. Mr. Delany, with his system, has certainly shown us that more can be done with one wire than was thought possible, and that any number of messages can be sent at the same time. The thing will look different when it is accomplished. Such a line might extend around the globe. You might work, say from the Congo River to Central America, by having a relay station at St. Helena. From Central America through the Pacific Ocean, having relay stations at the Islands and over to China, and from China then by land, and by short cables to the Congo River. For that continent I do not think will remain very long dark, and there will certainly be a telegraph somehow put through. A line might be established from the Cape of Good Hope to Buenos Ayres, and from Buenos Ayres to Valparaiso, and from Valparaiso to the South Sea Islands and Australia. I would like to hear any objections to that, if there are any. I have no doubt but that it will be put into practice, perhaps, before we arrive at 1900. Perhaps in twenty or twenty-five years, something of that kind will be arrived at, because it is rational.

Mr. KEITH:—There is one very pertinent objection to it, and that is that it has not been tried.

Mr. PARTZ:—It may be tried at any time now. There is nothing to interfere with it being tried.

The CHAIRMAN:—I would like to ask one question. If this theory is true, will it not be quite practical to try it on some small lake and settle the question before you attempt to cross the ocean; will not that settle the theory just as well?

Mr. PARTZ:—I don't know whether that could so easily be tried on a small scale. It would be rather difficult to try it on a small scale. You could not get a circuit of that kind, it would be necessary to take in the globe.

Mr. BEAR:—Mr. President, I believe the conditions are similar in a small body of water or earth as in a large—the largest, as the ocean, as suggested by Mr. Partz; or in a lake, or in a tub of water, the same conditions will obtain, I believe. This is simply the old method, which I quoted yesterday, of Professor Morse. Whether others were before him or not, I do not know. This is a matter of relative resistances, familiar to us all. That if two routes are offered for the electric impulse or current it will divide, according to Ohm's law, as Mr. Partz truly says, instead of running the greater distances between these earth connections, it will take a shorter distance, and it is perfectly rational and ought to be tried.

The CHAIRMAN:—Gentlemen, as we seem to have gone back to yesterday's business for a moment, I thought it might not be out of place to correct one misapprehension, which was brought up yesterday by the paper on underground wires read by Mr. Callender, and which I have heard expressed about twice a day for three or four weeks, and that is that the underground wire question has been settled once for all in Washington. The electrical people seem to have gotten the idea that somebody there has settled the question, and they are very fond of referring to that.

The facts are as follows: That the underground question in Washington has been thoroughly unsettled. I think some six or eight years ago Captain Green, who is quoted as the man who settled the question there, came to me to see what books I had on the subject. In looking over what I had, he picked out several volumes of the Journal of the London Electrical Engineers' Society. In that journal he found some report made by Mr. Preece on laying underground some telegraph wires between London and Manchester. He said at once that that settled the question, and that there was nothing more to be said, and he wrote a report to that effect. I think that he has never changed his opinion since then. Whether he has obtained any additional light on the subject, I would not undertake to say. At all events, the District Commissioners, who are the controlling military power of the District, have been issuing orders about semi-annually ever since, that no more wires should be strung overhead. Since they gave such an order the number of poles in the District, I suppose, have been doubled and quadrupled a good many times over, and what is of a good deal of importance, the poles have been erected by the National Government. The District government has always been erecting poles, and the number erected by the government has been very much larger than all the other poles in the city together, and the government has been setting up poles almost up to this day, and I think that they contemplate setting up more poles. During all this time the Commissioners have never, to my knowledge, asked Congress for a dollar of money, even to try any experiment with underground wires. But the great pressure that they have kept upon the private corporations has very much hindered the setting of poles, and has brought about quite a number of experiments with underground work. Two or three of the telegraph companies have laid some small number of wires in various ways underground. Some of them have worked, and some of them have not worked. The Waring Cable Company have, within the last year, been laying some few wires—three, four, or five wires, to connect some of the departments, at their own expense. The Telephone Company, under the pressure of the authorities, and under the general pressure of the demands for a greater number of wires, has made an experimental line of several hundred wires for about a mile with moderate success. They are preparing to lay some more wires, but the fact remains that the wires in Washington are not all underground. There does not seem to be any immediate prospect that they will go there. So that the gentlemen who are anxious for this, that the wires can and will work underground, will do well to look to some other city than Washington.

A paper read before the American Institute of Electrical Engineers, at Philadelphia, October, 1884.

CHEMISTRY OF THE CARBON FILAMENT.

BY EDWARD P. THOMPSON, M. E.

The object of this paper is to treat of the manufacture of the carbon filament from a chemical point of view, pointing out the chemicals from which it is to be made; the chemical actions which take place according to principle or experiment, or both; and the conditions which are necessary in order to obtain a filament of the maximum density, hardness, elasticity and homogeneity.

The principal lamps now being largely manufactured and represented at the Exhibition, and in which the filaments differ from one another by distinct chemical reactions which take place in their manufacture, are the Edison, the Swan, the Weston and the Stanley and Thompson lamps.

The Maxim lamp falls under the Swan and Edison in this classification, being distinguished from them only in the hydrocarbon treatment.

The filament in the Edison, Swan and Maxim is made from the same chemical substance, long known as cellulose, the formula for which is $C_6H_{10}O_5$. It possesses allotropic states in the forms of linen, cotton, paper and woody fibre, which differ widely in their physical properties, but show the above formula, by quantitative analysis, with the exception of a small percentage of impurities, which impurities may be neglected on account of their not being the cause of the difference of physical properties.

When subjected to dry destructive distillation, the hydrogen and the oxygen, together with the carbon in part, are separated only to unite again in different proportions and different groups to form new compounds, such as hydro carbons CH_4, CH_3, C_2H_2, etc., and the two oxides of carbon, besides numerous secondary products and oils and tars and pyrogallic acid and wood spirits, and in fact all the products which are evolved in the manufacture of coal gas, and more yet, due to the fact that the composition of cellulose is more complex than that of coal.

Very unfortunate it is that, during the carbonization of carbon filaments, much of the carbon is lost in the form of carbonic oxide and dioxide and hydrocarbons.

By calculation from the formula, it is observed that the carbon in cellulose occurs by weight to the extent of 44 per cent. only of the weight of cellulose from which it is obtained. The calculation is here shown, thus:

$$C_6H_{10}O_5$$

$$\begin{array}{lrcr} C_6 & 6 \times 12 & = & 72 \\ H_{10} & 10 \times 1 & = & 10 \\ O_5 & 5 \times 16 & = & 80 \\ \cline{4-4} & & & 162 \end{array}$$

$$72 \div 162 = 44 \text{ per cent. carbon.}$$

Although the cellulose becomes reduced in weight by carbonization, yet the specific gravity is not diminished. On the contrary it is increased considerably. A bamboo fibre will float on water, while the filament made therefrom will sink; so also with other forms of cellulose. This is on account of a contraction which takes place by the effect of heat and chemical reactions. Nevertheless, the carbon filaments are by no means as dense as if the carbon of the cellulose entirely remained after carbonization. In kilns for the manufacture of charcoal, the carbon which is removed is a larger per cent. than that removed from carbon filaments during their process of manufacture. This greater loss is due to its combining with the oxygen of the air, which is not wholly excluded from the kiln.

Filaments, being so small, may be baked in a crucible and the air removed or displaced by sprinkling fine graphite or carbon dust about the forms containing the filaments, or by the introduction of coal gas through a pipe. The former process is probably preferable, as it allows the highest temperature possible, while coal gas deposits large quantities of coke, which is likely to clog and build up the filaments irregularly when the temperature is maintained any length of time above the kindling point of coal gas. By either process, however, or by both combined, the oxygen of the air is practically excluded, so that there is no loss of carbon from this source.

By experiment, I have found that the carbon filament of the Swan, Edison and Maxim lamps does not weigh 44 per cent. as much as the cellulose filament from which it is produced. Calculation, it will be remembered, shows the above figure. In the experiment the air was carefully excluded. The carbons on an average weighed only 35 per cent. the weight of the cellulose, showing a loss of carbon of about 8 per cent. This is a very serious loss, as it causes the carbon to be 8 per cent. more porous than were no carbon lost at all. Further experiment showed that the loss can be reduced by certain precautions in baking, in the case not only of vegetable fibres, but also in that of animal matter.

The precautions taken were to raise the temperature of the crucible (which can easily be accomplished by a gas furnace) to a point just below that of the melting point of cast iron.

This increasing of the temperature should be made so gradually as to occupy several hours, and then should be maintained an hour or so at this temperature. Afterwards, it may be raised to the highest degree possible for one or two hours more. By this method of baking, it was found, as was expected, that the carbon occurred in a quantity approaching 44 per cent. within 4 per cent. instead of 8 per cent. The experiment proved further the principle that hydrogen will unite with oxygen at a lower temperature than carbon will unite with oxygen or hydrogen. If the temperature were regulated in exactly the right manner, there would be no loss of carbon. As this cannot be done even in the laboratory, and as it cannot be done with certainty in the factory, this method of saving the carbon cannot be of much use commercially.

Mr. Swan has endeavored to make the carbon dense by making the cellulose of cotton thread dense. The same percentage of loss of carbon occurs, however, as in ordinary cotton thread. The cotton or linen thread in this process, as carried on in the factory at Boston, is taken from one set of spools and wound upon another set of spools, which are situated at such a distance from the first set as to allow space for several large tanks, the first of which is full of sulphuric acid, one third water; the second with water, and the third with dilute ammonia, and the fourth with water.

The thread, by passing alternately below and above rollers, is caused to pass through the liquids in the order given. The sulphuric acid produces no chemical change, as is shown by subsequent analysis. It does, however, produce an important molecular change, so that the thread is three times as strong in tensile strength, is non-fibrous, of a pearly lustre, and as flexible as before treatment, its color still remaining as before. The rollers are rotated at such a rate as to allow the chemical to act on the thread about 15 to 20 seconds. Passing next into the tank of water, the excess of acid is washed away. The ammonia in the next tank neutralizes the remainder of the acid by turning it into sulphate of ammonia. The last tank washes away the sulphate, so that the thread is wound upon the spools, having only to pass between sponges to dry it. One physical change not mentioned above is the change of dimensions. The thread is larger than previously and is not of a regular and uniform diameter, showing that it could not have been acted upon alike at all points, which is not surprising when it is remembered that only 15 seconds are allowed and that the acid is itself weakened in its action as each molecule attacks the thread, causing acid of different strengths to act on different parts.

Temperature of the acid, as well as its specific gravity and time of action, very often produces worthless material for carbonization. The diameter is made uniform by drawing it through a die-plate, whereby it may not only be made uniform, but may also be made into various smaller sizes than the original.

The parchmentized thread is next wound upon two carbon rods supported at the end in holes bored into pine sticks. One of the sticks is removed during the winding, as it facilitates matters; especially as an instrument is employed which was invented by Mr. Swan for the purpose. It is wound about these two carbon rods in such a manner as to give the double curve noticed in the Swan filament.

I have often wondered whether Mr. Edison has ever tried to parchmentize the bamboo filament. It is already denser than cotton thread, as well as stronger, and yet nearly as flexible. There seems no reason why it cannot be thus changed in its physical nature by means of strong sulphuric acid. It is cellulose, just as truly as cotton, linen and paper are cellulose. For many years it has been known how to parchmentize paper, and yet it was only five years since Mr. Swan succeeded in making parchment from linen and cotton. I think that it would pay somebody to parchmentize wood. The new article would be valuable in many departments of industry.

I have referred heretofore to the subject of the loss of carbon, due to the process of destructive distillation; and now I wish to refer to it more particularly, and to point out the means which have been adopted in the lamp invented by Mr. Stanley and myself. Our object was to obtain as dense a carbon as possible, not only by producing such a chemical action during carbonization as would leave all the carbon as a residue, but also to introduce an additional amount of carbon by depositing the latter from a foreign substance introduced into the filament before carbonization, which substance would also be acted upon by chemical treatment. It may be mentioned that the carbon disappears by combining with the oxygen and hydrogen. Our process is found to cause all the oxygen to unite with the hydrogen, thus leaving all the carbon as a residue, and consequently leaving a carbon denser by 8 to 4 per cent. The process can be applied not only to vegetable fibre, but also to animal matter, which latter is employed in the manufacture of the lamps under exhibition. It is a well-known principle that sulphuric acid has a very strong affinity for water, and also for the elements of water when both elements occur in the same compound, as is the case in both animal and vegetable substances. An illustration of these principles may be observed when the acid is mixed with water. They immediately combine, with evolution of much heat. Also, if strong acid is poured upon sugar or syrup, the latter rapidly becomes hot, and intense chemical action is seen to take place. The final result is, that whereas we had sugar and acid, there now appears only a mass of carbon. The acid has taken away the hydrogen and oxygen in the proportion to form water, leaving free the carbon according to the following equation:

$$C_6H_{22}O_{11}+H_2SO_4=C_6+(H_2SO_4+11H_2O).$$

This reaction may be made to take place either by the strong acid, as indicated, or by weak acid plus heat. Take some sugar and moisten it with the weak acid, and heat gradually. If the acid were not present it is evident that the sugar would melt and turn into a thin liquid; but with acid and sugar mixed as described, the sugar turns into carbon by the application of heat without first melting, and the result is found to be a fine quality of the purest carbon; and if the acid and sugar are used in the right proportion, it is found by experiment that the amount of carbon remaining is equal to the amount calculated by the formula, which is as follows:

$C_6H_{22}O_{11}$.

$$\begin{array}{lcrcrcr} C_6 & = & 12 & \times & 6 & = & 72 \\ H_{22} & = & 1 & \times & 22 & = & 22 \\ O_{11} & = & 16 & \times & 11 & = & 176 \\ \hline & & & & & & 270 \end{array}$$

$72 \div 270 = 30$ per cent. of carbon in the sugar.

In the same manner it is found that sulphuric acid will blacken both animal and vegetable matter, and by the use of weak acid plus heat the substance is carbonized without loss of carbon and without destruction of solidity and density.

As our process involves these principles, and as the chemical actions have been verified by experiment and manufacture, it may be interesting and instructive to consider the process more in detail. The substance used may be any form of animal matter or cellulose; so that it will not be necessary to limit ourselves to the description of any particular kind of substance, further than to remark that we use animal matter, which gives a superior quality of carbon to that produced from vegetables. In the same manner as animal charcoal is found to be superior to vegetable charcoal in commerce, so it is found to be superior in electric lighting.

The substance is first prepared in the form of a thread. We form a mixture of sulphuric acid, water and sugar, by dissolving the sugar to saturation in a dilute solution of sulphuric acid. The proportion of water and acid is as 10 to 1. It may be noted here that this dilute acid will dissolve more sugar than the same volume of water by about 20 per cent. at the same temperature. The thread of animal or nitrogenous substance is wound upon large spools and immersed in the solution until every fibre is acted upon and until a chemical action has changed the character of the substance to some extent. This action is allowed to continue for about one week, while submerged in the liquid; but in fact it continues throughout the rest of the process, because the chemical preparation is not washed away, being allowed to remain in the substance during the carbonization. The excess of it is, however, wiped away by an apparatus invented for the purpose. The amount of the chemical mixture which is absorbed increases the weight by about 50 per cent., which represents an addition of carbon to a considerable extent, both on account of the addition of the total amount of carbon from the sugar and on account of the acid causing the retention of the total amount of carbon in the animal substance. When taken from the mixture and left to stand for several months it turns perfectly black and in truth commences to carbonize at the ordinary temperature, and, if left for years, would undoubtedly turn into carbon completely at the ordinary temperature. This is not, however, our process of procedure, although it is made to coincide with it as far as possible, *i. e.*, it is carbonized as slowly as practicable. After being wiped as to the excess of acidulated saccharine matter, it is prepared for the oven as now to be described. This step of the process relates to that of being able to carbonize a larger number of filaments in a space scarcely larger than that occupied by the filaments themselves. In the preparation of carbon filaments, it has been customary to form the fibre of the material which is to form the basis of the filament into the desired shape, and to subject it while still retained in that form to sufficient heat to remove other substances than the carbon. Each filament has most usually been formed into the desired shape and treated separately. The process used in this lamp consists generally in supporting a large number of the filaments which are to be carbonized upon a single forming block, the contour of which is similar to that which it is desired to give the filaments; while thus held upon the forming block in their required positions, subjecting them to sufficient heat to effect their carbonization. The form of the block upon which the thread or filament of an indefinite length is wound helically is such that when the filament is wound upon it, it will be bent into the form of loops, which have the shape it is desired should be retained by the carbonized filaments; and the prepared thread, after being wound upon the block, is retained in position by means of string or wire, or, in short, by a ligature wound transversely across the same. When thus prepared, the filament is cut at such points that single filaments are left each in the shape of the form. They are prevented from falling off the form by means of the ligature wound upon the same. The forms with the fibre upon them are then placed in a drying oven, which is slowly raised to a temperature of not less than a 100 degrees and not more than about 300 degrees C., so as not to reach the point at which sulphuric acid is vaporized. The water in the fibre is evaporated by the heat very gradually and quietly, and the sulphuric acid remaining in the fibre and growing stronger through the withdrawal of the water and through the increase of the heat, attacks and carbonizes without loss the sugar which has been taken up by the fibre. As the process is gradual and as there is present the acid, the sugar carbonizes into a hard compact mass which, being in the pores of the fibre, builds the latter up into a solid mass. In other words, it acts as a carbonaceous cement, making the structure non-fibrous and non-porous. If the acid were not present the saccharine matter would melt and run away. At the same time with the carbonization of the sugar, the fibre itself undergoes a chemical change through the action of the now strengthened acid upon it. It perhaps is impossible to state the exact chemical reactions which take place; but it is known that the nitrogen of the fibre is almost entirely removed from it and the fibrine it contains is entirely converted into new chemical combinations closely resembling one another and all extremely poor in nitrogen, such as leucine, $C_6H_{13}NO_2$; glycocine, $C_2H_3NO_2$, and tyrocine, $C_9H_{11}NO_3$.

The cause of these reactions depends upon the fundamental principle that sulphuric acid has a strong affinity for the elements of hydrogen and oxygen in the proportion to form water. In this way the hitherto nitrogenous animal fibre is converted into an essentially non-nitrogenous substance which will not be exploded into powder during the subsequent furnace carbonization, as would be the case if the nitrogen originally present in the fibre were allowed to remain, but can be readily converted into a tough elastic carbon of high specific resistance. If the fibre were exposed directly to the action of concentrated sulphuric acid, or of dilute sulphuric acid strong enough to attack it, it would be dissolved and destroyed before becoming fit for carbonization. However, as the acid is taken into the fibre in a dilute condition and then gradually becomes stronger, the action takes place slowly and throughout the fibre, as there is no free liquid present in which the resulting new compounds are dissolved, they being retained in the body of the fibre.

After the sugar is carbonized and the nitrogen is removed from the fibre, the forms containing the filaments are removed and placed in a crucible in a furnace heated to a temperature somewhat higher than that necessary to carbonize vegetable fibre, or about 3,000° F.

In the process of carbonization, the last trace of sulphuric acid is driven off, and any nitrogen that may have remained in the fibre is removed in the form of one of the gaseous oxides of nitrogen, and the result is a purely non-nitrogenous carbon. So much for the chemical actions during carbonizations.

While the high heat of the furnace acts upon the ligature, it is also carbonized, but being of a weaker nature than the filament, it breaks instead of the latter when subjected to the strain due to carbonization. By the time it breaks at all, the filaments are so nearly carbonized that they retain the shape of the form and do not curl and twist as would be the case were they not held to the form by the ligature. The best material to wind the filaments upon as a form has been found after numerous experiments to be carbon cut from coke, or the ordinary compressed carbon cakes cut into the required shape. Among the various substances tried were iron, and some other metals having high points of fusion, lime and similar refractory substances and wood. When wood is used, it is not necessary to cut the filament into individual filaments until after taken from the furnace, because the wood contracts proportionately as the filaments shrink; but the wood, however well seasoned, does not shrink regularly enough to keep the carbons in good uniform and regular shape. When iron is employed, the carbons are not of as superior a quality; for the iron will not absorb such oily products of destructive distillation as are given off during carbonization. The best substance to use is carbon, which may be employed repeatedly indefinitely; which absorbs the liquids and gases liberated from the filaments, and which at the same time is cheap and easily made. It is usually preferable to so construct the supporting forms that each complete convolution formed upon the same will produce two carbonized filaments, so that by cutting the same upon the opposite sides of the centre of the block, two loops will be formed having their ends confronting each other. In some instances it is desirable that the carbonized filament should have a greater breadth at the loop than at the ends—*i. e.*, to have it horseshoe shaped and not exactly U shaped—and for this purpose it will be desirable to construct the double form of supporting block of less thickness through its centre than near its edges. In winding the carbonizable thread upon such a block, it will be necessary to provide some means for permitting the same to be drawn down by the winding strings into the concave surfaces thus formed. To accomplish this result, suitable blocks capable of taking up as much of the prepared thread as will be necessary to allow it to be pressed into the hollow spaces are laid upon the sides of the block while the thread is being wound. These blocks are then removed and the subsequent winding of the supporting ligature presses the thread downward into the hollow or concave spaces, pressing it tightly against the surface of the forming block. By this process of carbonizing the filaments, their shape is free from any twist or curls, being of a continuous and regular shape corresponding exactly with the shape of the forming block. The forms may now be taken from the crucible, and by shaking them over a box all the carbons fall off in perfect shape, resembling in almost every property steel wire. In a crucible 6 in. × 6 in. × 6 in., 1000 carbons may be baked, all of which may be obtained without danger of breaking one or of finding one of irregular shape.

It is well known that when animal matter is subjected to destructive distillation it swells to several times its natural size and leaves it porous, with only small trace of carbon, of a shape anything but that of the mass from which it was carbonized, and consequently unfit for use as carbon filaments, even when the greatest precautions are taken as to excluding all air and as to regulation of temperature. The reasons for this behavior of animal matter under heat are in consequence of the presence of nitrogenous substances and a large quantity of water, held both by absorption and by chemical combination. The nitrogenous compounds explode into gases, with slight but comparatively strong detonations, and the water turns into a large quantity of steam, both of which cause a swelling and numerous eruptions, while the nature of the chemical reactions causes the carrying away of carbon in the form of gaseous compounds. By the simple process of soaking the animal or other varieties of nitrogenous substances in a saturated solution of sugar, in dilute sulphuric acid, for about one week, and then gradually heating to the highest temperature, without previously washing out the chemical solution, there is obtained a carbon filament of high specific gravity, and of considerable elasticity, hardness and strength.

Another new departure in the application of the hidden principles of chemistry to electric lighting is seen in the manufacture of the Weston lamp. In one of the eighteen large volumes of Gmelin's treatise on chemistry, are discovered the principles of the Weston process; but from the principles as there stated, no one but Mr. Weston probably would ever have attempted to apply them to the manufacture of the carbon filament. It is only by his persevering energy and repeated experiments that he ever succeeded in making a sizable and homogeneous mass large enough to make even one filament.

In Gmelin it is learned that when certain nitrogenous substances, such as gun cotton, collodion and albumen, are subjected to the action of sulphide of ammonia, protochloride of iron or tin, or cupra ammonia, the substance will thereby be deprived of its nitrogenous compounds, and will be reduced to a composition approximately similar to cellulose. I do not quote this word for word from Gmelin, but only from my memory of about a year and a half. These reducing agents have a strong attraction for oxygen, so that when left remaining exposed to the air for a short time a yellowish precipitate is formed which consists of the oxidized reducing agent. Sulphydrate of ammonia has a strong attraction not only for free oxygen, but also for oxygen occurring in other compounds, so that when a nitrogenous substance is placed in the sulphide, the oxygen is taken away in part from the nitrogen, while the remainder of the oxygen and nitrogen form one or more of the lower gaseous oxides of nitrogen, which escape and leave the substance practically free from nitrogen. This is the result of our investigation towards the exact chemical changes which take place, and which may or may not be found to be correct by further experiment. At the time of Mr. Weston's announcement of his investigation in this direction, we tried the manufacture of some experimental carbons according to his suggestions. We noticed great difficulties in obtaining any appreciable quantity of the substance which he has decided to call tamadine. Upon pouring the sulphide upon collodion, the latter at once turned opaque and white in spots and appeared fibrous, while upon investigation it proved to be non-fibrous. At these spots it was considerably tougher than the original collodion, but not so homogeneous as the collodion. By flooding the collodion with an excess of the sulphide, the spots of the changed substance were larger; but by repeated experiments we found it apparently impossible to obtain a large enough quantity for carbonization in the form of a filament. It was apparent, however, that the difficulties were due to mechanical and not to chemical difficulties. I have since learned that Mr. Weston is obliged to use large excesses of the sulphide, to use it at a fixed specific gravity and at a constant temperature. The quality of the results is best appreciated by viewing the samples on exhibition.

DISCUSSION.

The CHAIRMAN (Mr. W. D. Sargent):—Gentlemen, before inviting discussion on this most interesting paper which has been read, I desire to say that I have the honor to announce that we have with us this morning one of the most distinguished electricians of the present day. It is perhaps superfluous to name him—William H. Preece, of the British Postal Telegraphs. I desire to say that we honor ourselves much more than we can honor him by electing him to honorary membership. I trust that we will hear from Mr. Preece on the various subjects that come before us this morning, and we shall be very much satisfied with any remarks that he may make. (Applause.)

Mr. WILLIAM H. PREECE, London, Eng.:—I am afraid, gentlemen, that nature has deprived me of a power which I once held rather prominently, and that is the power of blushing; for if that power had remained, I think the sudden surprise of the remarks of your Chairman would certainly have brought to my cheek those colors which are now only to be produced by an artificial agency. Anyhow, whether the color comes or not the sensation remains, and I feel a sudden rise in the number of vibrations per second on my part, which tells me that I am excessively gratified by the receipt of the unexpected compliment paid to me. I assure you that if there is anything I can do for the purpose of furthering the interests of this young society, which I would like to see flourish, my services will be most cheerfully placed at your disposal. (Applause.)

The CHAIRMAN:—Discussion, gentlemen, is now in order on this interesting paper just read by the Secretary. I understand that there are several gentlemen present who are very competent to impart information on the subject, and we shall be very glad to hear from them. Will Mr. Kelly favor us with some remarks?

Mr. KELLY:—I have nothing to say, Mr. Chairman.

Mr. KEITH:—I know that there are several gentlemen quite competent to either criticise or indorse the paper that has been read. It seems to me that only natural timidity prevents them from getting up and saying something. Mr. Weston's name has been rather prominently mentioned in this paper as to a process of treatment. Whether the process, as here stated, is true or not, I would like to know if we can get such information. I hope Mr. Kelly, who is with Mr. Weston, will give us some few remarks upon this subject.

Mr. JOHN KELLY:—I might say the plan employed is practically that described by Mr. Thompson, and the difficulties met with by Mr. Thompson, in attempting to follow Mr. Weston's process, were the same that we met with ourselves previously, and it took a long course of experiments before we were able to overcome them. Now the article is manufactured on a large scale, and of course we do not meet with them to the same extent, because the material is prepared in large quantities; therefore the products are alike all the time. But the irregularities he spoke of meeting in the manufacture are likely be met with pretty constantly, because you cannot get collodion to contract regularly. That is a fact which should be mentioned.

Mr. Keith:—If I am allowed to get up on my feet again for the sake of getting information, I would say that Mr. Charles Stagl, connected with the Bernstein Electric Company, can give some information on the subject. The Bernstein lamp is a lamp of peculiar construction, and has excited a great deal of interest. It seems to me that Mr. Stagl might possibly, if he feels so disposed, give us some information as to the process of carbonization pursued by the Bernstein Company, or some information relating to the lamps.

Mr. Stagl:—I am very sorry I do not speak enough English so that I could explain it in the right way here for the society—especially this process which we are preparing. I am quite sure I have not English words enough so I could explain in the right way.

Mr. Keith:—There is another gentleman, Mr. Knowles, who, I know, has been experimenting for years on the carbonization of filaments for the carbon lamps. I will say this, Mr. President, that we are banded together in a new society—we are banded together for mutual improvement and information, and it is only by every gentleman who knows something, more or less upon various subjects, getting up and telling us something of his own individual experience, that will enable us to make our meetings interesting and our proceedings worthy of publication.

Mr. Knowles:—I am not prepared to say anything on the subject to-day, but I hope at some future time to make it the subject of a paper

A paper read before the American Institute of Electrical Engineers, Philadelphia, October, 1884; with discussion thereon.

DEPOSITING-VATS IN "SERIES."

BY H. B. SLATER, ELIZABETH, N. J.

Mr. **Slater**:—Mr. Chairman and gentlemen of the Institute, I do not expect at this time to present anything new or startling, especially to electricians; in fact I did not think it would be of interest to any one until it was suggested to me a short timea go that such a paper would be of interest to the meeting.

The subject of which I propose to treat is "Electro-Depositing-Vats in Series." Not exactly to treat of the subject, but simply to relate a matter of personal and practical experience, in that which, probably, all of us who have been in an electro-plating establishment have noticed. If we have noticed carefully, we have found that there was a great waste of the power employed for the deposition of metal. It has been my experience during the last seven or eight years, in many parts of the country, to find a high power running to waste through absolute ignorance of the principles of the force which the plates were using, and where they were acquainted with the facts which would naturally lead them to use it aright, they were either too lazy or too indifferent to make a proper application, so as to use them intelligently. As I say, I do not expect to present anything new, but I will simply call attention to a few facts and laws, and give the result of my experiments in the practical working upon a factory scale—that with an ordinary amount of information upon the subject, any plater or any electrotyper can apply these same principles and perform work with a small amount of power, compared with that which is generally used in such establishments.

If a current be passed through an electrolyte, containing a metal in solution, the quantity of the metal deposited in a given time will be proportional to the strength of the current.

This can be demonstrated experimentally with the voltameter, as follows: Introduce a rheostat into the circuit, and by varying the resistance it will appear that the gas or metal, according as either kind of voltameter is used, is deposited in direct proportion to the current strength. If we double the total resistance in circuit, we shall have half the current, while, if we halve the total resistance, we shall have double the current.

If several voltameters be connected in "series," it will be found that the law holds good for each one of the "series." The voltameter may be either the small experimental apparatus of the laboratory, or the large depositing-vat of the electro-plater; for the one is as truly a voltameter as the other, and the laws of definite electrolysis can be as well observed and carried out *practically* in the plating room, as *experimentally* in the laboratory.

The power consumed in electro-deposition is almost entirely used in overcoming the resistance of the circuit; viz.: the conductors, anodes, liquid and cathodes; hence any reduction in this resistance must result in a saving of power. This, of course, under conditions to be hereafter noted.

Resistance varies directly as the length and inversely as the cross-section of the circuit; hence by a decrease of length or an increase of cross-section we obtain a decrease of resistance, and according to Ohm's law a corresponding increase of current. It is plain then that with a given length of conductor, we can reduce the resistance to almost *nil*, or increase the length indefinitely, and still keep the resistance constant, provided suitable increase is made in the cross-section.

The resistance of an electrolyte depends upon the length of the liquid circuit, which is determined by the distance between the plates; and the area of the section of the liquid, which is determined by the size of the plates. It also depends upon the temperature.

I will now describe a "series" of depositing-vats in actual use on the factory scale, and working successfully for some time past.

Connected with a vat containing 200 gals. of metallic solution, I had a small dynamo machine. The work plated in the vat was all of the same size and kind, and sufficient to keep the machine constantly at work. The dimensions of the vat were: length, 6′ 6″; width, 2′ 6″; depth 2′. In it were three rows of nine anodes each, each anode being 8″×12″. One row extended from end to end of the vat at equal distances from the sides. The other two rows hung close to the sides of the vat, only one side of each of the side rows being exposed directly to the work. It will be understood that there were two spaces for work, one on each side of the middle row of anodes. As each side of the middle row of anodes was exposed to the work I had 6 + 6 = 12 square feet, and on the other two only one side of each row 6 + 6 = 12 square feet, giving a total of 24 square feet of anode surface. The distance between the plates or anodes on each side of the anode row was 15″.

The vat, with both rows of work filled up, held just 20 pieces, 10 on each rod. The articles to be plated were hung with their flat sides to the anodes, and as they were about 1″ thick it will be seen that the distance between anode and cathode was 7″. The resistance of the vat was .242 ohm between the terminals while full of work with the current passing. This included of course the $-e$. The E.M.F. of the dynamo $= 12.32$ volts after running 3 hours, and the resistance $= .2$ ohm. The resistance of the connections was practically nil, as the machine was close to the vat, and connected by a short, thick wire. By Ohm's formula we have $C = \frac{E}{R} = 27.87$ ampères. As the maximum current obtained was with an external resistance, equal to the internal resistance of the dynamo, it will be readily seen that there was very little waste of power.

On receiving orders to increase the output of work, it became necessary to increase the facilities for doing it, and an exactly similar outfit was placed side by side with the first one, including both vat and dynamo. I had experimented, about two years before, with vats in "series," and now resolved to put the idea into actual practice, as the work soon increased, so that the original output was more than doubled.

In each of the vats I placed another row of anodes, and so placed them that I had three spaces for work, instead of two, as before. This increased the anode surface by one-half ($\frac{1}{2}$) the original amount, viz., from 24′ to 36′, and as this increased the cross-section of the circuit in each vat by one-third ($\frac{1}{3}$), it of course produced a corresponding decrease of resistance. But by inserting this row of anodes the width of the vat was divided by 3 instead of by 2 as before. Originally the distance apart of the anodes was $\frac{30}{2}'' = 15''$, now it was $\frac{30}{3}'' = 10''$. The simplest calculation will show that these changes had reduced the resistance of each vat to less than 50 per cent. of its original value.

I now dispensed entirely with one of the dynamos, and connecting the two vats in "series" to the other dynamo, I set them to work and have every reason to declare it a success.

The vats are side by side, two (2′) feet apart, and the dynamo is placed between them at the end, connected by a short, thick wire from the + terminal to one of the vats, and by a similar wire from the vat on the other side of it to the − terminal.

On measuring up the series the dimensions were now found to be as follows: The E.M.F. was assumed to be as before, 12.32 volts; for it was the original machine, and ran at the same speed. Also the internal resistance of the machine was the same as before, .2 ohm. The external resistance between the terminals of the "series" was now, however, .2018 ohm, which added to .2 gives a total resistance of .4018. By Ohm's law, $C = \frac{12.32}{.4018} =$ 30.7 ampères.

As a result of the arrangement in "series," we have nearly 31 ampères of current passing through each vat, and a total effect of 61.4 ampères, compared with 27.87 ampères from the same machine through a single vat.

Further additions to this "series" can be made, but as the working space in the vats is as small as is convenient, it would be necessary to increase the *cross-section* by making additions of vats in "multiple arc," to compensate for the increase in *length* of the "series." In the case of the two vats described above, the additions to the anode surface, and also the work, were made in "multiple arc," and in any further increase of the "series," additions can be made by placing vats side by side, and connecting anodes and work as though they were one vat; and for every increase in *length* by addition to the "series," a corresponding increase must be made in the *cross-section* by an addition in "multiple arc." These additions in "multiple arc" must not be carried too far, however, as the ampère current per unit surface will thereby be reduced beyond the value which gives a satisfactory deposit.

I would say this "series" here treated consists simply of two vats, since increased to four vats, changing the size of the vats; but this "series" is simply of two vats in series, with a very small machine. The machine used was a shunt-wound machine, and automatic resistance in the shunt, by which the electro motive force was regulated to bring it down to the same amount.

DISCUSSION.

The **Chairman** (Mr. W. D. Sargent):—Gentlemen, are there any remarks on this interesting paper just read by Mr. Slater. We are ready to hear from any of the members.

Mr. **Keith**:—Mr. Chairman and gentlemen, as our honorable guest, Mr. Preece, has said to me, "This is your hobby," I may be supposed to be called upon to say something on the subject.

What I have to say will be very brief at this time, because I have a paper prepared on this subject, embracing the laws which govern it, and some remarks as to the practical application in electro-metallurgy on a more extensive scale than that of simply plating, namely, the production of pure metals. This point becomes very essential in the economy of such a process, and I have investigated it very extensively since 1876, and have put it into practice in quite a number of instances, which I need not now rehearse. It is, as Mr. Slater has remarked, of great importance to the electro-typer as well as to the electro-metallurgist, because by it he is enabled to do a much greater amount of work, as it increases his battery power. In the case of nickel, which he especially refers to, there is necessarily a little increase in the power by reason of the fact that there is some chemical decomposition which takes place in nickel vats. Some hydrogen is deposited, so far as my experience goes, with the solution of the double sulphate of nickel and ammonia; there is some hydrogen deposited with the nickel. The oxygen is absorbed by the other side, but the setting free of the hydrogen requires energy, and wherever action is to be repeated, as in the succession of vats, just that increase which is the multiple of the number of vats is necessary to effect that kind of decomposition.

That is different in those cases where there is no deposition of hydrogen, as in copper-plating and electrotyping vats. In those baths there is no absorption of energy in effecting electrolysis; in effecting the solution of the metal at the anode, the exact equivalent of the energy is set free to that required for the deposition of the metal upon the cathode. I ask Mr. Slater if he has made any experiments as to the amount of energy that is required to effect the deposition of hydrogen in the several vats. I presume that he has, unless he has made some other improvements for the evolution of hydrogen which is produced.

Mr. Slater:—I will say on that point that I have not the proper facilities for making extended trials in that direction. I have made some experiments, however, but what I have aimed to do is to reduce as far as possible the amount of hydrogen deposited. I think I have succeeded in that direction in a great measure by combinations in the solutions; that is to reduce the evolution of the gas. How far I have succeeded in that direction I am not prepared to say, not having the proper facilities for making the experiments. That will remain for some future work. I think, however, that in the solution produced by me at present the amount of hydrogen deposited as compared with the amount deposited in the sulphate solution is very small indeed. I came to the conclusion some time ago that it was hardly worth while to notice that in my practical work except for information.

Mr. E. A. **Sperry**:—I noticed in the reading, a statement something like this, as I understand it, that the deposition of metal went on much better when the interior and exterior resistance was equal.

Mr. **Slater**:—I would say in that regard that I have found that the principal difficulty in my work has been to bring down the resistance of the external within proper limits. Unnecessary resistance is, of course, a waste of power. To avoid useless resistance the dynamo was placed as close to the vats as possible, and all connections were made as large as possible, consequently the resistance was all in the actual work, and the work going on at its best.

Mr. E. A. **Sperry**:—As I understand it, these conditions named are those that exist when the maximum amount of work is done, and it stands to reason that the most economical system would be with the greatest exterior resistance on the exterior circuit if sufficient ampère current would warrant the insertion of the vats. Ofc ourse too many vats would reduce the ampères of current, until the amount deposited per second, per minute, or per hour, would be such as would render it not an economical system. Other than from that consideration I do not see any reason for reducing the exterior resistance. That would interfere with the interior resistance of the dynamo.

Mr. **Slater**:—The vats are so placed and connected, that the only considerable resistance is in the vats themselves, and by suitable arrangement in "series" and "multiple arc" the total resistance of the vats will not exceed the proper limit and the ampères of current will not be reduced.

Mr. **Keith**:—Mr. Chairman, I desire to state the matter in this way: that if we have one vat of a given area of surface, say one square foot, and pass the current through it, we get a product of one. There is no expenditure of energy except the mere overcoming of the resistance of the circuit. If we add to the number of vats so as to place them in a series, we are obliged to increase the energy applied to effect the passage of the current in proportion to the resistance to the current implied by this addition of another vat. There is no more counter electro motive force chemically produced to be overcome. Now if we place two more vats in series and in parallel, so as to make a multiple series arrangement, as made and shown by these four squares, we then have exactly the same resistance as before. There is just as much current as before; there are two translations by reason of the series, and at each translation we produce the amount of electrolysis that is due to the current passing. In case we have four vats we divide the current between this two series, so that in each vat there is just half as much electrical action, or deposition of metal, as took place before. But we have four vats; four times one-half produces two, which is twice the deposit made before, with the expenditure of no more energy. In case of nickel decomposition, the setting free of gases which I referred to before, there is an increase in the energy necessary to pass the current through the vats in series, and that increase is necessitated by counter electro motive force produced by the evolution of the gas. I may say that this whole subject is to be treated of in my paper, and as it will probably be found that there will be no time to bring the paper out at this meeting it will duly be published in the proceedings, with diagrams illustrating the points. For the practical application of it I again refer you to the paper read by me before the Institute of Mining Engineers, upon the plant at Rome, N. Y., where lead is treated in vats in series of ten, which are there working. Thirty were put up, but have not been working on account of defects in the vats, defects causing the leakage of the electrolysis. But of the ten vats in series, I would say, they demonstrate practically all the principles that have been set forth in this paper of Mr. Slater, and in the paper which I shall bring before the Institute, either directly during the session, or in its printed publications.

Mr. Kelly:—I desire to ask for information. If I remember the experiment there is a certain amount of chemical corrosion going on all the time; it takes a certain amount of current to balance that chemical corrosion. Now, in arranging the vats in multiple series you reduce the density of the current. For instance taking four you have only one-half of the current you had before. The amount of increase of surface lessens the current. I think that proposition was right—that there was a chemical corrosion going on, and that you must ultimately reach a point where the density of the current would be reduced, and where it would balance the corrosive effect.

electrically produced in the electrolyte. Now if we placed two more vats in series and in parallel, so as to make a multiple series arrangement, as illustrated here by these four squares, we then have exactly the same conditions as before. There is just as much current as before; there are two electrolyses, by reason of the series, and at each electrode we produce the amount of electrolysis that is due to the current passing. In case we have four vats we divide the current between the two series, so that in each vat there is just half as much electrical action, or deposition of metal, as took place before. But we have four vats; four times one-half produces two, which is twice the deposit made before, with the expenditure of no more energy. In case of nickel decomposition, the setting free of gases which I referred to before, there is an increase in the energy necessary to pass the current through the vats in series and that increase is demonstrated by counter-electro-motive force produced by the evolution of the gas. I may say that this whole subject is to be treated of in my paper, and as it will probably be found that there will be no time to bring the paper out at this meeting, it will duly be published in the proceedings, with diagrams illustrating the points. For the practical application of it I again refer you to the paper read by me before the Institute of Mining Engineers, upon the plant at [illegible], N. J., which was treated in vats in series of ten, which has been working. Thirty were put up, but twenty had not been working on account of defects in the vats, defects causing the leakage of the electrolysis. But of the ten vats in series, I would say, they demonstrate practically all the principles that have been set forth in this paper of Mr. Slater, and in the paper which I shall bring before the Institute either directly during the session, or in its printed publications.

MR. [illegible].—I desire to ask for information. If I remember the experiment there is a certain amount of chemical corrosion going on all the time; it takes a certain amount of current to balance that chemical corrosion. Now, in arranging the vats in multiple series you reduce the density of the current. For instance taking four you have only one-half of the current you had before. The amount of increase of surface lowers the current. I think that proposition was right—that there was a chemical corrosion going on, and that you must ultimately reach a point where the density of the current would be reduced and where it would balance the corrosive effect.

A paper read by Mr. C. J. Kintner, before the American Institute of Electrical Engineers, at Philadelphia, October, 1884; with discussion thereon.

THE PATENT OFFICE: ITS RELATION TO INVENTORS AND ITS NEEDS.

I owe an apology to your honorable body for presuming to come before you with a paper of such hasty preparation as this has received; but it was only upon Saturday last that your Secretary advised me he would be pleased to have me prepare and present it.

It is needless to remark that I should not have dared attempt this preparation in so short a time, had I been forced to collect data from existing publications alone; and also, that it is only through my immediate connection with the Patent Office, through a series of years, as a member of its Examining Corps and as chief clerk, that I have been so familiarized with its workings, its needs and its relations to the public, as to enable me to give you briefly a history of its existing condition and all bearings thereon.

There is, I may safely say, no individual portion of that greatest of legal efforts, our National Constitution, which has been the foundation of such universal benefit, as section 1, article 8, which provides that all authors and discoverers shall have the right to the exclusive use of their productions and discoveries for limited periods of time; and upon this authority our forefathers, with, it would seem, a providential foresight in 1790, originated the first revised statutes concerning patents, thereby granting to inventors an exclusive right to the use of their inventions for limited periods of time, in consideration of a full and free disclosure thereof; this right to accrue to the public after the limited period has expired.

With very slight modifications the law of 1790 remains in existence, and our Government possesses to-day the best patent system in the world. As a result, inventive genius has been stimulated through this hope of reward, by the production of untold thousands of valuable inventions everywhere. I need not recount to you how we are transported from one metropolis to another at miraculous rates of speed; how our great harvests are gathered and carried to the four quarters of the globe at rates of speed that fifty years ago would have been seriously questioned—aye, absolutely denied; how our methods of communication have been improved, so that to-day contracts are made between London and San Francisco before the time of their actual date. In other words, that we actually ante-date time. Nor need I spend time in recounting the thousands of useful inventions, all covered by patents, that are daily crowding our homes, making life easier, existence happier, and adding in a thousand ways to our comfort, our intelligence and our mutual instruction; in short, elevating mankind. How many of the American people of to-day ever give this subject a thought, but rather take it as a matter of course. Yet I make bold to say that but for our patent system, executed under existing laws, we would to-day be in the condition of some of our sister European nations, struggling for a bare existence.

Indeed, our system has not only proved beneficial to us, but has stimulated the world at large, and to-day statistics show that nearly or quite one-half of the patents taken out in England, Germany, France, Italy and other countries, are by American inventors. It needs no assertion of mine to prove this; we have but to turn to the patent records of these Governments to ascertain this fact. I know it has been customary to attribute our individuality as a nation to the fact that we are peculiarly an energetic people, made up of the better elements of all classes of humanity and stimulated by the idea that this is a great free country, and that in each individual there lies the probability of the Presidency, to be looked at in the dim distance through the political horoscope; or of the untold wealth of a Rothschild to be hoped for from a financial standpoint, if perseverance and economy are prevailed in; but I make free to assert that this individuality of Americans is due to the labors of just two classes of persons, viz.: the Author and the Inventor, both of whom look to their success through the hope of protection of their respective industries for at least limited periods of time; the one by copyright, and the other by the patent system.

It is to the author that we owe our public schools, our culture, our tastes for arts and sciences, and all that goes to make life more elevated. It is to him, as a scientist, that we are indebted for research into the mysteries of life, inquiries as to how we may make life longer and free it from pain and sorrow; in short, he brings us nearer to the Creator.

It is to the inventor that we are indebted for all the comforts of life and the conveniences for interchanging thought and elevating our minds. He has given us the printing press, upon which to unfold, in expressible language, the best thoughts of our friend the scientist, and to prepare for both the youth and the older scholar food for thought. He has joined hands with the scientist, and unfolded to our gaze the mighty depths of space, revealing millions of unknown worlds, and myriads of unknown miniature creatures in the microscopic world. Where can we look about us and not see the work of his industry?

In the face of this progress, can there be found a person, who will seriously consider all those great advancements in the arts and sciences, and say that our patent system has not been almost wholly instrumental in it?

I take it that no argument is necessary upon such a question, as statistics will show. Where can be found to-day the inventor who labors for pure love of his productions, disconnected from a possible fortune in limited protection? Look over the list of great inventors, whose inventions have revolutionized the world, and show me a single instance of an inventor, since the commencement of the present century, who has not sought protection under our patent laws in some shape.

Let us now turn briefly to the question of the effect of patented inventions, and I will illustrate by a few examples how inventions open up new fields of labor, and furnish employment for thousands before otherwise employed, thus increasing the field of productive labor. Take the manufacture of cotton alone. Statistics show us, the Commissioner of Patents, Butterworth, advises me, that if all the men, women, and children of this country were constantly employed, night and day, they could not, by the old method of carding, prepare the cotton now raised in this country for the loom.

It is also known that were all the men, women, and children of New England employed constantly at pegging and sewing boots and shoes, they could not perform this work upon the material manufactured in and about the City of Boston.

These figures are startling, but have been gathered from an actual review of the work done.

So I might continue to show what patented inventions have done. How the telegraph, the telephone, the railroad, and thousands of other inventions have increased a thousand fold the field for labor; but this is only offered to show why our patent system should be fostered with the care it deserves.

Turning, now, to the Patent Office proper, I find it was formally established in 1836, when it became a part of the Interior Department, under the control of the Secretary of the Interior, and these relations have since been maintained, but little change occurring, save in the matter of increase of force.

The force, as originally constituted, did not embrace more than ten persons in all, the Commissioner of Patents included, and the annual issue of patents to, and including, 1840, was very meagre, indeed.

Since that time there has been, with two or three exceptions (notably during the civil war), a steady increase, until now the annual issuance is over 20,000, and the total number granted above 300,000; the total number of applications filed last year being over 40,000.

While this increase of patents has occurred, the increase of force and conveniences of accommodation in the matter of the examination of applications and issuance of patents have fallen sadly in arrears.

The present force of the Patent Office numbers, in all, about 550, and is apportioned approximately as follows:

Assignment Div	100
Draughtsman Div	125
Examining Corps	150
Issue and Gazette	75
Chief Clerk's Div	100
	550

I will recount briefly the duties of each of these divisions, and their existing conditions.

1st. The assignment division is employed in recording all assignments of patents and records appertaining to patents, and is, briefly, to patent property, what your well-known office of records and deeds is to real property—an office of record.

Besides this, the force is employed in furnishing copies of all papers ordered for suits at law, copies of files and contents, and generally of the papers of the office, when called for in court and other proceedings, whether under seal or otherwise. The requirements upon this division are enormous, as you may well imagine, when you come to consider the enormous amount of litigation growing out of over 300,000 patents, more than 200,000 of which are still in legal force.

The force is not at all sufficient for the needs of the office, and the division is months behind in recording deeds and furnishing copy. A delay caused by this arrangement may, any day, embarrass interested parties thousands of dollars.

2d. The draughtsman division. This division has charge of all matters appertaining to the drawings of patents, both before and after issue; collects the drawings, stores and classifies the patented drawings and specifications as the patents issue, so that when copies are ordered they may be had at short notice; supervises the photo-lithographing of drawings, and keeps the lists complete by reproduction as they expire; classifies the photographs for examiner's use, and also for the use of attorneys and others making preliminary searches in the office, as to novelty.

It also has charge of the matter of mounting foreign drawings for the use of examiners in their various divisions; pasting together the specifications and drawings of patented files, &c. The work of this division is sadly in arrears, owing to the increased issues of patents for the past two years.

3d. The issue and Gazette division is employed, as its name implies, upon the matter of preparing patents for issue, and to this end the work embraces proof-reading, indexing, numbering, preparing the patents, and editing the *Official Gazette*—a weekly publication, of about 100 pages, quarto, devoted to keeping a correctly classified record of all patents as they issue, giving names of inventors in each case, date and number of patent, title of invention, claims, &c., &c.; and in general containing all matter concerning the general conduct of office business—such as Commissioners and Court decisions, general orders appertaining to official changes of classification, &c.

The work of this division is up, and must be kept up, to the exclusion of other work, for the patents must issue when they take their date and number, and the weekly *Gazette*, like any periodical, must not fail to come forth on time. However, there is need of more force here, if it could be had, and a minimum force is employed, so as not to cripple other divisions too badly.

4th. Chief clerk's division embraces all the force immediately under the supervision of the chief clerk of the office, and is employed as follows:

1st. Financial division, where all moneys paid into the office are received.

2d. The mail division, where all mail matter is received, regulated, and properly distributed, and all outgoing mail properly classified and forwarded.

3d. The application division, where the applications for patents, with all amendments and papers appertaining thereto, are received, numbered, entered in registers, and forwarded to their proper examining divisions.

4th. The scientific library, where all printed publications and foreign patents are received, catalogued, and shelved, for use of the examining corps and inventors.

5th. The interference and appeals division, wherein are kept all records of contested cases and appeals, ex parte or otherwise.

6th. The model department, where are stored all patented models, which are carefully classified and catalogued, for future reference and use.

The chief clerk also has charge of all correspondence, wherein inquiries of a general nature are made, and is the confidential adviser of the Commissioner, and has general supervision of the whole office force, looking after the individual wants of various official divisions, and supplying, through the proper channels, all necessary articles for the conduct of business, such as furniture, fuel, stationery, &c. This force is insufficient, but, like the issue and Gazette division, is of vital importance, inasmuch as it has to do with the financial portion of the machinery, and it is important that the correspondence and immediate demands upon the office be attended to promptly, so it draws from the other divisions to keep the work within limits.

The last, but most important, division, touching the validity of patents, is the examining corps.

The official classification of patentable subject matter is divided into 26 divisions, representing 25 branches of the arts and sciences, the 26th division being the Court of Interference, or contested cases.

These 25 divisions have each their Supervising Officer, known as the Examiner in Charge, and under his supervision are four assistants, grading from 1st to 4th assistant inclusive, with salaries ranging from $1,800 to $1,200 per annum.

The Principal Examiner is supposed to be well skilled in the art he has chosen to supervise, and to have a thorough knowledge of patent law and practice; and his assistants are required to be proportionately well skilled in all such matters, and are, I think I may safely say upon the whole, as efficient a body of men as could be desired. It is the duty of these men to pass upon the applications which come before them as to novelty and utility. They are the judges who, in nearly ninety-nine cases out of a hundred, pass finally upon the applications coming before the office. In other words, they grant the patents. They should be well posted in matters of the arts, at least to such an extent that they know whether a device is operative or whether it is novel in view of what has been before done in the same art, reference being had to prior patents—domestic and foreign—and to printed publications and public use.

To obtain men of this class, it has been the custom for ten years or more, to hold competitive examinations for the lowest grade and for promotion in the several grades upon technical matters, and to this end the Patent Office claims to be the father of civil service reform. The class of men appointed under such a course has been found to meet the requirements effectually, and so far as efficiency is concerned, I think, with few exceptions, there can be no objection to the existing force.

The only matters I want to especially urge upon your honorable body are—1st, the need of greater force generally for the office; 2d, more room; and 3d, a mechanical and chemical laboratory or workshop for the Examining Corps.

It is needless for me to say that for the past ten years Commissioners of Patents have, without exception in their annual reports, urged upon Congress the necessity of the first two of these questions. But as earnest as have been their individual efforts in this direction, I must say that with due regard to all of them, none have done more or appreciated more kindly the wants of the office than the present commissioner, the Honorable Benjamin Butterworth. Through his efforts the force has been increased during the past year about 10 per cent., and additional space to the amount of twenty rooms added, by forcing the Indian office out of the building.

First, then, as to the question of force. If the increase of force of the Patent Office had kept pace with the rapid increase of the patent business, and with its requirements necessitated by the great business interests of the country, resulting from patented profits and litigation thereon, it would, instead of numbering 550 employees, to-day number over 1000.

Take the Patent Office reports from 1850 to July 1st, 1884, together with the immense interests which have accrued in that interim and compare statistically if you will the forces employed at those times and the emergencies in the nature of the case, and you will ascertain that my figures are rather under than over the estimate.

As a result of the insufficient force now available and the cramped quarters occupied by the Examining Corps, many of the divisions are months behind. In harvesters, one of the most important classes of inventions, they are fourteen months in arrears; in textile fabrics over eight months; in my own class, in which you are especially interested, over five months; so that were you to file an application to-day it would be, in all probability, five months before I could even take it up for examination.

Now, gentlemen, this should not be. You, the inventors in the electrical art, have a right to demand that your interests shall be more promptly attended to than this; and you ask me why the delay? It is simply because there is and has been for the past ten years an impetus in inventive genius such as the world never before witnessed. It is not spasmodic, it is not to-day, or to-morrow, or next year that this is to cease, for the indications are that this great people are on the very verge of an onward wave of progress, such as was never before known to the civilized world, and the wonders of to-day are only noted to-day to be eclipsed to-morrow by the culmination of something which is the result of Yankee ingenuity, only more wonderful than that which preceded it; so that we begin to think that perhaps after all there is a probability of all things being possible even within the brain of that humble creature, man.

In the prospect of this great era of inventive age—not only in its prospect but in its reality, there is a future more prolific than all the past and a future of realization without doubt. And the necessities of the case demand an absolute increase of force in all the divisions of the Patent Office, for the reason that as the various arts advance more exhaustive knowledge of them must be had.

Patents and publications must be briefed and reduced to manageable limits, so that an examiner can make his searches more expeditiously and give to you patents which are what they seem to be, valid contracts, both as to novelty and utility.

In this connection, much has been said about our system as compared with the English, where a patent is granted on every application presented, without search as to novelty. If I had time I would show you the fallacy of attempting to prove that the English system is cheaper in the end, and would show you how our system stimulates invention by causing inventors to study more closely an art to improve upon existing patented devices. But at some future time I may present a paper on the comparative systems and will treat of the matter fully there. Suffice it to say our system is infinitely cheaper in the end, and undoubtedly so if we make it as efficient as we should by providing the necessary qualified force, so as to make searches as to novelty exhaustive, as was the intent of the law.

2d. As to the question of room. I seriously wonder how many of the visitors to our beautiful National Capitol are aware of the fact that the great and magnificent building known as the Patent Office proper, and illustrated in our public libraries and wherever shown as the Patent Office, is in fact occupied only in a small part by the Patent Office.

Built by the money of the inventor, wrung from him with the idea that he is to have for his preliminary fee of $15 (little enough it is true, but nevertheless paid for a special purpose), that he is to have, I say, an exhaustive search; that his patent is to be a valid contract as to novelty, so far as human search can determine; that with the surplus of the money thus taken from the inventors this building has been built, and commodious rooms and halls, to be occupied, not by the Patent Office and an efficient corps of examiners, to do that for which the Government contracts, but by the Interior Department, consisting of the Land Office, the Railroad Office and the Indian Office, a portion of the Examining Corps being crowded down, as Senator Platt so truly in his speech before the Senate said, "into the coal vaults and cellars of the building; part of the model hall having been captured and turned into quarters for the Land Office."

Such are the facts; and to-day the Electrical Division is occupying two small rooms on the ground floor under which there is no cellar, and the walls are so damp and quarters so crowded as to cause much sickness. I desire to call especial attention to Senator Platt's speech, upon his bill, for making the Patent Office a separate department, under control of the Commissioner of Patents. It can be had by addressing the Clerk of the Senate.

The Government should, in duty to its trust with inventors, see to it that the Patent Office has especial control of the whole building, and has such facilities as the necessities of the case demand.

There are other examiners who are in much worse rooms than it is my misfortune to be, and are occupying those rooms which some years ago were used as coal cellars.

The 3d question I wish to present to you is the necessity for a thoroughly organized laboratory and workshop in the Patent Office. This is a feature to which I have called attention more than once at the office, and during my imcumbency as Chief Clerk in 1883 I was instrumental in obtaining a meagre appropriation of $200 towards establishing a chemical laboratory. Such was the nucleus of the existing laboratory, the total value of all the material to-day being less than $500.

Now, gentlemen, what do you think of a bureau of scientific experts upon mechanical, electrical, and chemical technics, without any mechanical workshop, without any electrical apparatus, and with a laboratory having a total valuation of less than $500.

Here am I, the electrical expert of the United States Patent Office, as head of the electrical division, expected to pass upon your inventions, coming, as they do, from a society of highly educated, practical, experimental electricians, as to their utility, their operativeness, and their results, without any of the modern appliances of experimental apparatus.

What apparatus have I, do you say? Well, let us recount the complete stock.

1st. Ten cells of Bunsen's battery, presented to the office by Chas. E. Buell.

2d. One small hand dynamo, presented to the office by Chas. J. Van Depoele.

3d. Two small galvanometers, of old pattern, without any attachments, other than needle circular gradations and binding posts; both presents to the office.

You, doubtless, would like to know how I pass upon the efficiency of certain devices, such as instruments for overcoming induction, testing telephones, the efficiency of batteries, &c. In reply, I simply add, I don't pass at all, but pass the case to issue, if it is not too flagrant a violation of well established principles, and not contrary to well accepted theories, a policy, you must admit, not the most wise in these days of advancement, when old theories crumble before experimental facts.

Now, gentlemen, this should not be. The Patent Office should, as the head centre of the records of inventive genius, at least do what it pretends to do, grant patents for actual working apparatus in every instance, and an examiner should be morally certain that a device works as it is claimed to work, that a process evolved brings about the result specified, or that a composition of matter does all that is claimed for it. No alleged inventor should be allowed, under the guise of law, to impose upon an unsuspecting public, simply because the government has seen fit to grant him unwittingly a fraudulent patent.

To this end, I hold it is your duty, as inventors and as good citizens, to see to it that the Patent Office is provided with the material, both in the nature of a sufficient force and of experimental apparatus, to the end of the public good.

The question naturally follows, how shall we accomplish this end.

Gentlemen, it lies with you, the inventors, and with the corporations and business interests using patented inventions, and not with the employees of the office, to bring about the results I ask, and I will point out, as briefly as possible, how it may be accomplished.

It may not be generally known to you, but it is true, that there lies to the credit of the inventors of this country, and of such other countries as have obtained patents of the United States, nearly $2,000,000, over and above all actual expenses incurred in granting those patents. Money wrongfully extorted, and now lying dormant in the Treasury. Several attempts have been made of late in Congress to turn this fund over to educational purposes, but, so far, without avail.

There goes annually into the same deposit over $200,000 surplus, above the annual expenditures of the office.

Now, I submit, that this money is the property of the inventor, levied for a special purpose, and cannot, under the Constitution, be misappropriated. In other words, you are, as a class of people, being virtually robbed every year of $200,000.

What, then, is your duty?

It is plain enough.

You must go before Congress and express, in language unmistakable, your desires in this direction. You must buttonhole your individual members of Congress, and give them to understand plainly what you want in this direction. I tell you, gentlemen, there is nothing works upon a member of Congress like a pressure from his immediate constituents.

The average congressman is a selfish creature, ever watchful of the public pulse, particularly when that pulse beats feverish in his own immediate district.

It is then your duty to go individually and collectively to your representatives and place this issue before them. Obtain copies of the Platt bill and speech, and read it. Urge the necessity of its passage, and put the Patent Office on a footing such as the advanced position of this great free government demands.

Let us have an increased force of examiners, at salaries justified by the position they command.

Let us have the whole of the Patent Office building. It is yours to command, and purchased with your funds.

Let us have all the facilities we demand, and when this occurs we will be provided with expert examiners equal to the emergency, who when they become proficient and useful in their calling shall not be tempted to more lucrative positions outside the Patent Office, as is now daily the case. In this connection I desire to call attention to the fact that one of my assistants has resigned since your last meeting, and another will go out within a month to fill a position at an advance of salary.

I shall have to educate new men to fill their places, only to lose them when they become proficient.

Doubtless you ask yourselves why I display so much interest in the matter of increased salaries. Is this increase of salary sought through selfish motives, is this increase of room for mere self comfort?

No, gentlemen, I beg to advise you that I can at any day leave the Patent Office, at an increased compensation above my present salary, and have been asked within the year to accept a partnership in a firm practicing patent law, where I am guaranteed over $3,000 per annum.

I make these requests in the interests of the office, and add, by way of conclusion, that when I do seek a livelihood elsewhere it will probably be in the patent business; and desirous of speedy action and accurate work on the part of my successor, I think the measures I have to-day advocated will be also heartily indorsed by every practitioner who comes before the office. And in conclusion, gentlemen, let me hope you will not permit this matter to drop here. You may rest assured you will find in the present Commissioner, Hon. Benjamin Butterworth, a hearty co-laborer, who is ever ready to aid the inventor and is alive to the interests of the public good, and appreciates to-day more than any other public man that the position we occupy as a nation is due more to our inventive genius, stimulated by the best patent system the world ever knew, than to any other cause.

DISCUSSION.

The **Chairman** (Mr. W. D. **Sargent**):—Gentlemen, Mr. Kintner's most interesting paper is before you. Are there any remarks upon the subject?

Mr. C. J. **Kintner**:—I would be very much pleased to answer any inquiries that may be made upon the subject.

The **Chairman**:—Can we hear from Mr. Jannus on that subject?

Mr. **Jannus**:—I fully indorse all Mr. Kintner has said. The thing we suffer most from is that the average congressman when he comes to Washington feels that he has a great field before him, and instead of really coming down to the consideration of the few much needed changes in the Patent Laws, getting letters from his constituents concerning patent matters, he uses his time trying to bulldose the Commissioner into ordering immediate action on his particular case. Now if his case is made special it disposes of all the interest he has in the matter of patents. The men that bother him are satisfied, his case is terminated, and the rest may wait. This is simply inexcusable, and I am glad to say, less successful now than formerly.

You can hardly appreciate the position of a Washington attorney, but if any of you had forty or fifty cases pending in Mr. Kintner's division and were receiving letters every day, and people were coming into the office every day and inquiring why has not my case been acted upon, you would be nearly worried to death. You go to an examiner and ask about a case. He will refer to it; it is among fifty packages of papers, perhaps half way down; you inquire when it will be reached, he looks ruefully at the pile before him and replies "Well, about three months or so," and that's the best you can do. Now this is the condition of affairs, as Mr. Kintner has shown, in his division, and his is not the worst.

I remember about two years ago a harvester case was talked of in connection with myself as attorney. A week ago I carried the model of that case to the Patent Office. The case had been nearly two years before the Patent Office before it was taken up, and then the first thing the examiner did was to call for a model. That is simply an outrage. Mr. Kintner has very well said that every man, woman and child in the wheat growing districts, if they worked all the time, night and day, would be absolutely unable to harvest one-tenth of the crop grown. There is no question as to the value of these inventions! There is no question as to the progress that has been made in this business, and the instance I have named is an example. That division, covering mechanisms as important as any other, is nearly two years behind-hand, and the matter is getting worse and worse every day. There does not seem to be any chance for relief.

Now, as to the so-called Patent Office, it is a misnomer. It is a Land Office with a patent office attachment. I go into one examiner's room, finish my business and want to see the head of another division. I have to go all around the Patent Office building, which occupies two entire squares, nearly a quarter of a mile, to get to the next examiner's room, just because there happened to be a room there which nobody else wanted, so it was used for this purpose.

I only offer these remarks in corroboration of what Mr. Kintner has said, and to call your attention to the fact that making a case special is not the way to help what I believe might so easily be made the best patent system known.

Mr. Kintner:—Mr. Jannus' remarks bring one matter very forcibly before my mind, and that is the manner in which the Commissioner, Mr. Butterworth, has been enabled to increase our force ten per cent.; and when I say that the increase of ten per cent. has been made during the time when the Presidential contest was going on, it is something remarkable in the history of the office. It is only by reason of the fact that General Butterworth has positively forbidden the making of any case special. When members of Congress come to ask him to make a certain case special, the reply is, "Gentlemen, I cannot do it." He simply says in so many words, "I would not do it for my grandfather." I have seen a whole delegation from Congress come before the Hon. Commissioner of Patents, both Senators and Representatives, to urge, with all the power they could make use of, that the cases of their constituents be made special; and I have yet to find that the Hon. Commissioner has once changed his opinion in that respect. And it is largely upon this basis that he has been enabled to force upon Congress the idea that we must have an increased force in the Patent Office. You can very readily see what has been the result from the Commissioner's refusal to make any case special.

General Butterworth has had the manliness to come out and say, "Gentlemen, I will not make a case special for any one of you." There is only one way in which a case can be made special, and that is under the rules where the head of a department shall specify that the invention for which the applicant is calling for a patent is of such general and public welfare to the Government that it will be deemed necessary to make it special, and to take it up at once.

In reference to this, I wish to add, that unscrupulous inventors have taken advantage of this fact, to go before the heads of the various departments to urge their cases, I mean before the secretaries. In this way, in some instances, cases have been made special that were not meritorious. I know that has been done in my class, and I have called the attention of the Commissioner to the matter, and he has used his powers, so far as possible, to prevent the violation of this rule.

You see the rule is a necessary one. In time of war it may become necessary to patent some particular apparatus of warfare, and patent it speedily; it may be necessary for the Secretary of War to take advantage of this rule, and he may make a request to that effect. Unscrupulous inventors have sought to evade the rule, and in this direction, I am thankful to say, that even there, there has been a stop put to it, and we now shall soon have the Patent Office on the footing that we desire. Within the past six months we have been able to turn the Indian Office from the Patent Office building, and have gained twenty rooms; and the Commissioner has made attempts in other directions. I hope ultimately the Patent Office will occupy the whole building, and that we shall be placed upon a basis such as the Patent Office deserves.

I might have said much more in this paper, but it seemed to me very long as it was. I have only given you the general outline of the manner of conducting business in the Patent Office. It seems to me that you, as inventors, and you as a particular class of inventors, who have necessarily much power before Congress, can do much in this direction. I urge you, therefore, again, strenuously, to do what you can to aid us.

Just one word more as to the members of the examiner's corps now in the Patent Office. I want to explain more fully the condition under which we are placed by having examiners leave the office, particularly in my class. During the time I have been connected with the Patent Office, since the year 1880, the entire personnel of the Electrical division has changed. I went in as second assistant in 1880, and there is not one of the force at that time there who is now in the division, except myself. From the examining corps, I was promoted to the position of Chief Clerk, afterwards to Examiner in charge of the Electrical division, and in that time the entire personnel of the division has changed three times. What is the result?

I take it that I need not go into the question of showing to you of what use is the process of examination as to novelty or in what that consists. It simply amounts briefly to taking up each application in its order, and ascertaining whether the invention is novel or not. To do this it is necessary that each examiner should be thoroughly familiar with his particular art. Take, for instance, the class of dynamo machines. This is a class now involving between 500 and 1,000 patents in the American list alone, and it involves I should say 1,000 English patents. It involves in the matter of publication no one knows how much.

Now the most important portion of the electric art has been developed within the last ten years. It is not necessary for me to tell you this, it is well known to all of you. Within that time we have not one line of briefs of English patents, and we have not one line of briefs of American patents; and we have not one line of briefs of the publications of the day; but the whole state of the art is carried in the head of the assistant examiner who is under my charge, and in my own head too.

We all of us know that it is not safe to trust to memory upon a question of searches in patentable matters. The assistant in charge is liable to leave me at any time, and, when he goes, he carries away everything he knows. I am under the necessity then of putting in a new man, who must learn everything afresh, and the result is invalid patents are issued—patents very detrimental to other inventors. I have not anything more to remark upon the question. I think you fully appreciate the condition of the office, and will do what you can towards putting it upon a sound footing.

Prof. **Edwin J. Houston**:—I think it is a very fortunate circumstance that Mr. Kintner has brought this matter before our attention. It is certainly an important matter, since it touches the future patents in our country, and I am glad that a person officially connected with the Patent Office, as Mr. Kintner is, expressed himself so fully in regard to this matter.

We all know the great difference which exists to-day between the English Patent Laws and our own. In England, I believe, they have reached that state, in which a patent is issued as a matter of course. The result of this is, that the patent papers issued by the English Government are practically worthless until a case is tried by the courts.

Mr. KINTNER:—It is so, as a matter of course, if they don't know otherwise. If they happen to know it is patented in the United States, they will not grant a patent; or if there is anything against it.

Mr. HOUSTON:—They do not make a search upon which the value of the patent depends. Now, it seems to me, that we are fast approaching the time when either we must make more careful searches or must practically abandon our patent system, and give a patent as a matter of course. There can be no doubt as to the advantage our system has over the English. It seems to me to assure the value of all patents that are granted, it is absolutely necessary that there should be placed in the hands of the examiners and patent officials such a laboratory as Mr. Kintner has suggested. If it is necessary for an inventor to have all the modern scientific appliances at his disposal to make inventions, it is equally necessary for examiners to have at their disposal such appliances as will permit them to see whether the things claimed are novel, and whether certain combinations are workable or not. I do hope some action will be taken in this direction. It will do more to advance the interests of inventors than probably any other thing we can do.

Mr. N. S. KEITH:—Mr. Chairman, I merely suggest the remedy; and that is that every one of us members who knows any congressman, or who knows any friends who know any congressman, endeavor to influence that congressman in favor of the Patent Office, and in favor of the patentee.

There is what is called a strong granger influence adverse to patents. Men who are so short sighted as to think that the duty that they are paying upon reapers, mowers, binders and so forth is a mere duty from which they do not gain any advantage and from which they can gain no advantage. But if this subject is brought to them properly, to the effect that if they had no binders, no reapers and mowers, their crops would cost them far more, and that they would never be able to gather them, they would understand the matter better. The farmer has undoubtedly suffered somewhat because of wrongfully purchasing, innocently enough, apparatus for which he has had to pay again thereafter; but it argues nothing against the patent system, and the protection which it gives the inventor.

Mr. Maynard:—I would like to inquire whether there is any necessity for a legal requirement that cases should be acted upon in the order in which they are presented. As the practice now is it depends upon the judgment or whim of anybody who happens to hold the office of Commissioner of Patents. I understand that applications are sometimes marked "special in the order of specials." There seems to be an order of special and regular papers.

Mr. Kintner:—I will explain. The law indicates the order in which applications should be taken up. Also the rule of practice indicates the order in which applications are taken up. They are taken up as I said upon the authority of a Secretary of one of the departments for the reason above given. They are taken up also when an application has been previously patented abroad for a very obvious reason that the American patent, which is limited by the life of foreign patents, has its life already begun. You catch the idea; it is that with the patent previously taken out abroad its term is shorter than seventeen years. The American patent is limited by the foreign patent, therefore its life has begun to run and it must be taken up at once. If it is a re-issue application for a patent already granted, where the patentee is seeking to protect his claims, or for obvious reasons is seeking for a change in his patent, or in some other way to correct it, it must be taken up because the life of the patent is already running.

As to the question of order of specials, that refers to the papers in the office and has no reference to an application. Sometimes papers are filed and there is an order calling for copies. Copies of important papers are needed to be used in court during the progress of a suit, or before the Supreme Court, or before other courts where it is absolutely necessary that the copies should be before that court on a certain day. Cases of that nature occur, but they have nothing to do with applications. I am speaking merely of copies of papers; cases of that nature are sometimes made special by the Commissioner, and they are made special, in the order of specials. These specials take the preference over any other for obvious reasons, but that has nothing whatever to do with the question of the issuance of patents. It is merely where such papers are to be used in court or otherwise, where the copies are required.

Mr. MAYNARD:—I would like to ask one more question. There are some neighbors of Mr. Jannus who claim that they have special facilities for obtaining patents. How is this?

Mr. JANNUS:—You will see something of this kind advertised every day. Every conceivable inducement is made to get an inventor's business, and the sole end and aim of these persons is to devise, or imagine, or get some one to suggest to them, some scheme that is plausible and they will advertise it. All they want is plausibility, and they work on that to an extraordinary extent. Really their circulars are comical. A fair idea of the official estimate of their responsibility may be obtained from Patent Office rule 17, which says in substance that it will be *unsafe to trust* those who pretend to have any better facilities for obtaining patents than diligence and skill in their profession.

I will just relate a little experience of mine recently, and you will see what to think of special facilities.

A firm in New York filed a case belonging to a class that is considerably behind-hand. Of course it took some time to be reached. When it was reached references were given, and they did not leave much of the case. It was not an electrical case by the way. Well, in order to bring out what was left of the case more fully, a new drawing was made illustrating the part, the specification was revised and the claims restricted to that particular feature. The examiner made a further re-search and then cited references which did not leave much of that. The result being that after fighting over the case for some time they got a final rejection. The attorney thought there was something novel in the case, and that it had been fully brought forth, and therefor advised an appeal to the Board. Now then the applicants in this case thought they would try some of the special-facility men. So they revoked the power of attorney of the original solicitor and placed the matter in the hands of a special-facility man. This *expert* met the same fate as his predecessor and the case remained finally rejected; so what did he do? He re-prepared the application under a different title, copied the drawing identically, had another man swear to the papers, and filed the case in the Patent Office, as I say, under another title, so it went to another examiner.

Now there are one or two regular moss-backs among the examiners, men who don't make any examination to amount to anything. If they think the thing is new, they sign the papers. Their work is always up. They don't have any trouble and they don't care whether the thing is novel or not. They are all right as to their cases, they know.

Mr. Kintner :—That is the English system.

Mr. Jannus :—It is an exemplification of it. This case went to one of the very worst of these men and he took it up. He attended to it himself to make it a still better job; he looked at the outside of the file, didn't think he had anything like it, passed it out, and in six days from the time it was filed the attorney had the patent allowance.

That attorney crowed over the others and said, "I am the man who can get you a patent. I have special facilities."

Now, gentlemen, in the first place somebody had been guilty of perjury, somebody else had been guilty of a most outrageous trick, and as matter of fact, the references on which the original application stood rejected came out of the second examiner's class. I know of these facts, and that the record upon which the original application as rejected came out of the second examiner's class. Last but not least it may be well to add that a patent granted as above is simply a snare and a delusion, and about as worthless as a second-hand poultice, for the references applicable to this (or any) case are always accessible to any one desiring to ascertain the *value* of a patent.

APPENDIX.

American Institute of Electrical Engineers.

RULES.

I.

OBJECTS.

THE objects of the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS are to promote the Arts and Sciences connected with the production and utilization of electricity, and the welfare of those employed in these industries; by means of meeting for social intercourse, the reading and discussion of professional papers, and the circulation, by means of publications among its members and associates, of the information thus obtained.

II.

MEMBERSHIP.

The Institute shall consist of Members, Honorary Members, and Associates. Members and Honorary Members shall be professional electrical engineers and electricians. Associates shall include persons practically and officially engaged in electrical enterprises, and all suitable persons desirous of being connected with the Institute, and duly elected as hereinafter provided. Each person desirous of becoming a member or associate shall be proposed by at least three members or associates, canvassed by the Council, and elected by a majority of the members and associates as expressed by letter-ballot to a regular meeting of the Council, and shall become a member or associate on the payment of his entrance fees and dues for the first year. Each person proposed as an honorary member shall be recommended by at least ten members or associates, and be elected by the Council; *Provided*, that the number of honorary members shall not exceed twenty. The Council may at any time change the classification of a person elected as associate, so as to make him a member, or *vice versa*. All members and associates shall be equally entitled to the privileges of membership; *Provided*, that honorary members shall not be entitled to vote or to be members of the Council.

Any member or associate may be stricken from the list by the vote of three-fourths of the members of the Council, due notice having been mailed in writing by the Secretary to the said member or associate.

III.

DUES.

The entrance fee shall be five dollars for each person. The dues of members and associates shall be ten dollars per annum, payable in advance at the annual meeting. Honorary members shall not be liable to fees and dues. Any member or associate may become, by the payment of one hundred dollars at any one time a life member or associate, and shall not be liable thereafter to annual dues. The dues of members residing in foreign countries—beyond the seas—shall be five dollars per year, but such members shall have no vote for election of members. Any member or associate in arrears may, at the discretion of the Council, be deprived of the receipt of publications, or stricken from the list of members when in arrears for one year; *Provided*, that he may be restored to membership by the Council on payment of all arrears, or by re-election after an interval of three years.

IV.

OFFICERS.

The affairs of the Institute shall be managed by a Council, consisting of a President, six Vice-Presidents, twelve Managers, a Secretary and a Treasurer, who shall be elected from among the members and associates of the Institute, at the annual meetings, to hold office as follows:

The President, the Secretary, and the Treasurer for one year (and no person shall be eligible for immediate re-election as President who shall have held that office subsequent to the adoption of these rules, for two consecutive years), the Vice-Presidents for two years, and the Managers for three years; and no Vice-President or Manager shall be eligible for immediate re-election to the same office at the expiration of the term for which he was elected. At each annual meeting a President, three Vice Presidents, four

Managers, a Secretary, and a Treasurer shall be elected, and the term of office shall continue until the adjournment of the meeting at which their successors are elected.

At the first meeting for the election of officers, a President, three Vice-Presidents, to serve one year; three Vice-Presidents, to serve two years; four Managers, to serve one year; four Managers, to serve two years; four Managers, to serve three years; a Treasurer to serve one year; and a Secretary, to serve one year, shall be elected.

The duties of all officers shall be such as usually pertain to their offices, or may be delegated to them by the Council or the Institute; and the Council may in its direction require bonds to be given by the Treasurer. At each annual meeting the Council shall make a report of proceedings to the Institute, together with a financial statement.

Vacancies in the Council may occur by death or resignation; or the Council may by a vote of the majority of all its members, declare the place of any officer vacant, on his failure for one year, from inability or otherwise, to attend the Council meetings or to perform the duties of his office. All vacancies shall be filled by the appointment of the Council, and any person so appointed shall hold office for the remainder of the term for which his predecessor was elected or appointed; *Provided*, that the said appointment shall not render him ineligible at the next annual meeting.

Five members of the Council shall constitute a quorum; but the Council may appoint an Executive Committee, or business may be transacted at a regularly called meeting of the Council, at which less than a quorum is present, subject to the approval of a majority of the Council, subsequently given in writing to the Secretary, and recorded by him with the minutes.

V.

ELECTIONS.

The annual election shall be conducted as follows: Nominations may be sent in writing to the Secretary, accompanied with the names of the proposers, at any time not less than thirty days before the annual meeting; and the Secretary shall, not less than two weeks before the said meeting, mail to every member or associate (except honorary members), a list of all the nominations for each office so received, stamped with the seal of the Institute, together with a copy of this rule, and the names of the persons ineligible for election to each office. And each member or associate, qualified to vote, may vote, either by striking from or adding to the names of the said list, leaving names not exceeding in number the officers to be elected, or by preparing a new list, signing said altered or prepared ballot with his name, and either mailing it to the Secretary or presenting it in person at the annual meeting; *Provided*, that no member or associate in arrears since the last annual meeting shall be allowed to vote until the said arrears shall have been paid. The ballots shall be received and examined by three Scrutineers, appointed at the annual meeting by the presiding officer; and the persons who shall have received the greatest number of votes for the several offices shall be declared elected, and the Scrutineers shall so report to the presiding officer. The ballots shall be destroyed, and a list of the elected officers, certified by the Scrutineers, shall be preserved by the Secretary.

VI.

MEETINGS.

The annual meeting of the Institute shall take place on the third Tuesday of May, at which a report of the proceedings of the Institute, and an abstract of the accounts shall be furnished by the Council. Two other regular meetings of the Institute shall be held in each year, at such times and places as the Council shall select, and notice of all meetings shall be given by mail, or otherwise, to all members and associates, at least twenty days in advance. Special meetings may be called whenever the Council sees fit; and the Secretary shall call a special meeting on a requisition signed by fifteen or more members. The notices for special meetings shall state the business to be transacted, and no other shall be entertained.

Every question which shall come before any meeting of the Institute, shall be decided, unless otherwise provided by these Rules, by the votes of a majority of the members then present. Any member or associate may introduce a stranger to any meeting; but the latter shall not take part in the proceedings without the consent of the meeting.

VII.

PAPERS.

The Council shall have power to decide on the propriety of communicating to the Institute any papers which may be received, and they shall be at liberty, when they think it desirable, to direct that any paper read before the Institute, shall be printed in the Transactions. Intimation, when practicable, shall be given, at each general meeting, of the subject of the paper or papers to be read, and of the questions for discussion at the next meeting. The reading of papers shall not be delayed beyond such hour as the presiding officer shall think proper; and the election of members or other business may be adjourned by the presiding officer, to permit the reading and discussion of papers.

The copyright of all papers communicated to, and accepted by, the Institute, shall be vested in it, unless otherwise agreed between the Council and the author. The author of each paper read before the Institute shall be entitled to twelve copies, if printed, for his own use, and shall have the right to order any number of copies at the cost of paper and printing, provided said copies are not intended for sale. The Institute is not, as a body, responsible for the statement of facts or opinion advanced in papers or discussions at its meetings, and it is understood that papers and discussions should not include matters relating to politics or purely to trade.

VIII.

AMENDMENTS.

These Rules may be amended at any regular meeting by a two-third vote of the members present, provided that written notice of the proposed amendment shall have been given at a previous meeting.